ELECTRICAL ENGINEERING

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The Cover: View of test stands for large turbines that are part of the Westinghouse Electric Corporation's expansion program at its Steam Division, South Philadelphia, Pa. Eight 250,000-kw units, or up to 20 smaller units, can be assembled and tested on these stands at one time.

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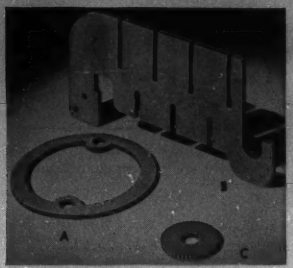
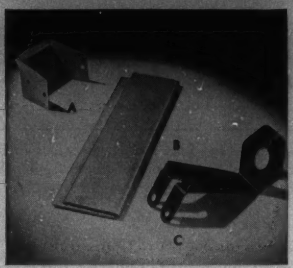
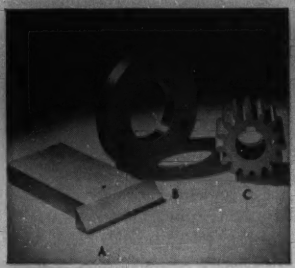


A. Sheet stock, shear strips, punch. B. Sheet stock, shear, punch blank, gang saw notches. C. Sheet stock, shear strips, punch blank, mill notches.

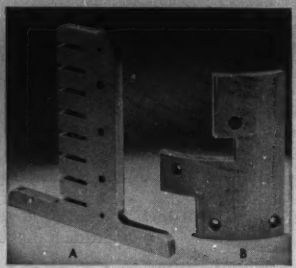


A. Sheet stock, shear strips, punch, form. B. Sheet stock, shear to size, drill, form. C. Sheet stock, shear strips, punch pieces, form in mold twice, rubber stamp twice.

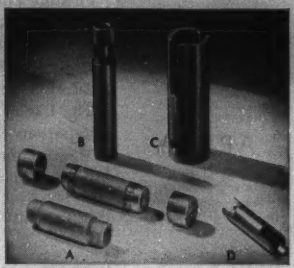
A. Rod (hexagonal), smooth saw, automatic screw machine, turn shoulder thread, champfer and cut off. Remainder are automatic screw machine parts made from Diamond Fibre by C-D-F.



A. Sheet stock, sand, smooth saw to size, smooth saw bevel, smooth saw corner cut out, drill. B. Sheet stock, band saw, turn OD, bore ID, smooth saw side, drill five blind holes with jig. C. Sheet stock, sand, band saw, rough bore ID, hob teeth, finish bore ID, machine keyway.



A. Sheet stock, sand, smooth saw, drill, smooth saw to shape, radius three corners, gang saw notcheses. B. Sheet stock, band saw rough blanks, form, smooth saw width, length and shape, radius edges, drill with jig, countersink.



A. Tube, automatic screw machine, turn shoulders, champfer and thread end, thread other. B. Tube (long pieces), smooth saw, tap threads, screw machine, (small pieces) auto. screw machine, thread, knurl, champfer, cut off. C. Tube, smooth saw to length, punch twice, countersink. D. Tube, automatic screw machine, champfer, cut off, punch.

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HIGHLIGHTS.....

Increase in Annual Dues. AIEE President Monteith's letter to AIEE members explains the Board of Directors' recent action in raising the members' annual dues, an act that "is long overdue" (*p. 273*).

Election Procedure for Institute Officers. Each spring the AIEE membership receives ballots containing the names of candidates for officers of the Institute for the next year. Every Fellow, Member, and Associate should be familiar with the procedure by which candidates' names arrive on this ballot (*pp. 278–80*).

Engineers and Our National Well Being. This is an examination of our security position as regards the communists. Topics covered include: "the technological race," manpower, atomic energy, and nuclear power. The author also makes suggestions concerning a unity organization to represent the engineering profession in professional matters (*pp. 295–7*).

What the Engineer Has Meant to Communication. The vital role of the engineer is indicated by tracing his contributions during the last 75 years as well as his current and anticipated future contributions and responsibilities to communications systems (*pp. 274–7*).

Safety Aspects of Nuclear Reactor Control. A review of the kinetic behavior of a reactor as a power source is given. The mechanisms by which a nuclear accident could be created and the means of preventing accidents of this and other types are discussed as well as the basic elements of reactor safety system design (*pp. 306–9*).

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High School Teachers of Science. The supply of science high school teachers has been inadequate in recent years, so that steps have been taken by the Engineering Manpower Commission and the Scientific Manpower Commission Joint Committee on High School Teachers of Science to formulate a plan for improving the condition. The proposed plan of action, as presented, is an initial step to alleviate the situation (*pp. 304–5*).

Economic Counsel and Modern Management. Acceptance of economic counsel by management has been retarded. Management should be made aware of its value since the present-day economic goal "demands of us the best we can contribute in the way of economic understanding and skill" (*pp. 298–302*).

Grounding of Portable Electric Equipment. The products involved are portable appliances, tools, and lighting equipment designed for use on the 120-volt 2-wire or 120/240-volt single-phase 3-wire grounded neutral branch circuits required for general purpose interior wiring in Article 210 of the National Electrical Code, 1953 revision (*pp. 286–91*).

Electronic Pulse-Type Fault Locator Experience. This relatively inexpensive method of locating faults on transmission lines is primarily for finding sustained transmission faults. The equipment, its operating experience, methods of coupling, and the problem of personnel training are discussed (*pp. 282–4*).

Equations Depicting the Operation of the D-C Motor. A way to develop mathematical systems utilizing straight lines or simple curves to represent ordinary d-c motor performance is given. It is dealt with in terms of both the shunt and the series motor (*pp. 316–21*).

The Use of Tone Modulation Over Complex Carrier Channels. After discussing briefly the three types of modulation by a tone being used at present, carrier channel transmission characteristics and their effects on modulation are treated, and finally corrective measures to improve carrier-channel as a transmission medium are offered (*pp. 310–4*).

Possible Energy Trends. The author appraises the future position of nuclear energy in comparison with conventional sources of power which are now used (*pp. 292–4*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Development of the RCA 21-Inch Metal-Envelope Color Kinescope. The kinescope described in this article represents a successful solution of the problem of designing a large practical high-quality color kinescope which can be made in production quantities. A description of a new phosphor application method, and factors affecting register are discussed (*pp. 330–5*).

Digital Computer Plug-In Units and Associated Equipment. A line of small plug-in units for digital computing systems has been developed. The type of construction used greatly reduces the time between the inception of a logical system and its practical realization. It also permits rapid duplication or modification of a system once a stockpile of basic units is available (*pp. 326–9*).

Maintenance of Electric Beam Pumping Equipment. Rather than offering a complete classification of specific maintenance factors, the intention is to indicate the importance of obtaining inexpensive quality electrical maintenance especially in terms of technical and operating standards. The electrical maintenance costs of two areas are compared (*pp. 324–6*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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New loss-of-field relay provides automatic protection of machine and system

When a synchronous machine loses its field, both the machine and system stability are seriously threatened. Low excitation can lead directly to thermal damage of the machine. In addition, the machine may go out of synchronism and draw sufficient reactive power from the system to upset system stability.

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All relay components are coordinated to prevent false tripping in event of low-voltage conditions alone, or external faults. The relay is adaptable to all types of synchronous machines without modification.

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A. C. MONTEITH, PRESIDENT
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Dear Member:

After careful consideration your Board of Directors voted on February 3, 1955, to increase the annual dues $5.00 for all AIEE members, except students.

As I am sure you know, this increase in dues was not the result of any hasty decision. For several years your Board has been aware that steadily increasing operating costs were inevitably going to force us to raise our dues. Anticipating such a need, the situation was placed before our membership in April 1951 and you voted to authorize your Board to increase our dues when absolutely necessary. During the past several years, by improving our operating efficiency, we have been able to delay raising dues and yet carry forward all essential Institute services to our members.

However, time has run out. Despite recent extensive efforts to hold expenses down, plus the added revenue from a 20 per cent increase in advertising rates for *Electrical Engineering*, it was clear that by April 30, 1955, we would be operating at a rate of $100,000 a year in the red. With other possibilities fully explored, an increase in dues was the only solution left for balancing our budget.

You will be interested to know all comparable professional societies long ago raised their dues: it is a tribute to our Institute's thrifty operation that we are the last to take this step. Many of you who knew of the Institute's problem and who did not like the idea of waiting to act until we were definitely in the red have written to me to say, "This is long overdue." As a matter of fact, most of us are paying the same dues as charged 50 years ago.

The underlying cause of our deficit is that services to members have been steadily expanding and their unit cost rising, without a comparable increase in income. For instance, last year each member received an average of $24.70 worth of services; but member dues averaged less than $12, and income from all sources still was inadequate to pay the bill. The recent increased publications services for our expanded technical activities are costly because of increased cost of labor and materials. Membership, Sections, Student Branches, meetings and the like have grown rapidly during recent years, but not as fast as unit costs. These are just a few facets concerning our financial problem (which has required a dues increase). You will find more detailed discussions of our situation in the lead articles of *Electrical Engineering* for December 1954, and January and February of this year.

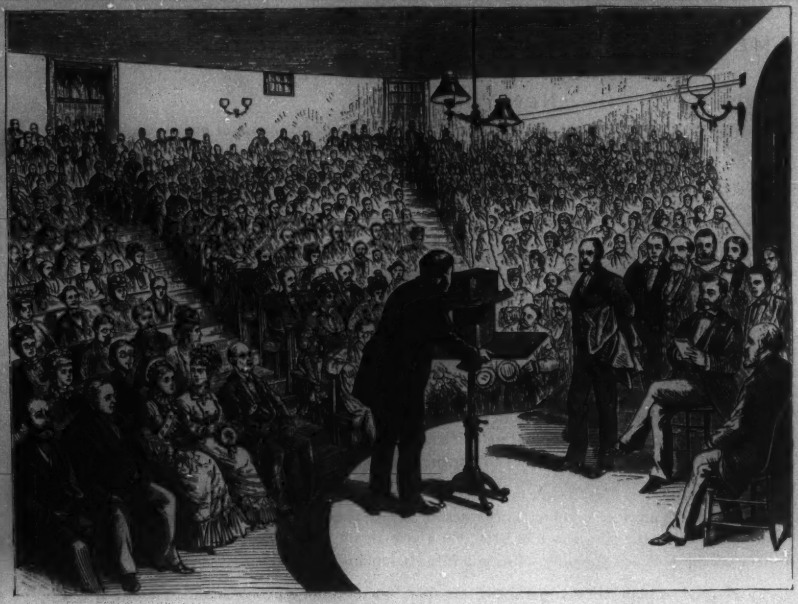
I think you may be interested to learn your Board intends investing a modest amount to try to find how best to plot our course for the years ahead. We are going to take a good cold look at ourselves in two steps. First, a scientific survey will be used to give us an idea of what you members really want. Second, with clear-cut objectives of what members want before us, outside consultants specializing in organization will study our operation and recommend how to establish an organization to meet the objectives. The Institute is still working with about the same organizational setup and operating just about the same way it did over 30 years ago, when the membership was only about one third its present size. But many changes have taken place in this period, and we believe out of the study will come an Institute that will better meet the needs of its members and give us a bigger value for our dues than ever before.

Although your officers were hesitant to increase Institute dues, basically they did it to further your interests. Therefore, for your part, I would like to suggest that each member give the Institute and the Board of Directors a tangible expression of appreciation and confidence by sending back a check for 1955–56 dues on the day the bill arrives.

Sincerely yours,

A. C. Monteith

President



Trial exhibition of Bell's telephone, March 15, 1877. Professor Bell is shown in Lyceum Hall, Salem, Mass. addressing scientists in Boston

What the Engineer Has Meant to Communication

E. W. ENGSTROM
FELLOW AIEE

The importance of the engineer in developing the art of communication is considered. The discussion includes his increasingly vital role from the 1880's up to the present time and an examination of future trends and responsibilities.

THE subject of the engineer and his communication, both within and outside his profession, is an especially important one to all engineers in view of the increasing reliance upon technology for continued prosperity and national security. My part in this discussion today appears to cover much territory. Asking what the engineer has meant to communication is akin to asking what the architect has meant to building construction.

Modern means of communication are very much the product of the general technological development. They comprise the electronic transmission of sight and sound, the swift and efficient transportation of men and goods to all corners of the world, and the rapid mass distribution of the printed word and picture. These systems have been created largely through the ability of the engineer to translate new scientific knowledge into a flow of products and services for public use.

This states only in the most general terms the dependence of today's communication upon the variety of engineering talents that have been available during the past 50 to 75 years. This occasion, the 75th anniversary of the founding of The American Society of Mechanical Engineers (ASME), provides a logical framework for dealing in specific terms with the principal engineering contributions to the communications systems of today and tomorrow.

Essentially full text of an address presented at the 75th anniversary meeting of The American Society of Mechanical Engineers, New York, N. Y., February 16, 1955.

E. W. Engstrom is with the Radio Corporation of America, New York, N. Y.

COMMUNICATION FOR THE AVERAGE MAN

Consider, for example, the circumstances of my presence here today. My part in the proceedings began with a telephone call from Mr. Marshall. On the following day, a typed letter was received confirming the arrangements for my participation and enclosing a mimeographed draft of today's program. This morning, I got into my car in Princeton to drive up the New Jersey Turnpike and through the Lincoln Tunnel, arriving in little more than an hour at the RCA Building. I rode up in the elevator to my office on the 53rd floor in a fraction of a minute. I remained long enough to make and receive a few telephone calls, to read a telegram and to scan a few letters, at least one of which had been posted only yesterday from a city more than 1,000 miles away. And now I am describing these routine happenings over a public address system which eliminates any strain on my voice or your ears.

This prosaic description of an average day in the life of an average business man happens to involve nine communications facilities which were either nonexistent or existed only in a rudimentary state when the ASME was organized in 1880. The list includes the telephone, the modern typewriter, the mimeograph machine, the automobile, the express highway, the vehicular tunnel, the high-speed elevator, air mail, and the public-address system. And before today is over, I shall most probably experience some contact with radio and television—two more of today's standard communications media which did not exist in the world of 1880.

In that distant year, the art of communication stood at the threshold of a series of revolutionary developments leading into an era of expansion. The only means of rapid communication over relatively long distances was the telegraph. The telephone was just coming into being, and only 47,000 instruments existed in the entire United States.

PRIVATE AND MASS COMMUNICATION IN 1880

Private communication in 1880 was thus largely a matter of personal contact or letter post, and, occasionally, in emergencies, the telegraph. Business correspondence employed the typewriter to some extent. Mail depended upon a combination of machine and animal for delivery.

Mass communication in 1880 was restricted entirely to the printed page in books, magazines, and newspapers. Even the publications of 1880 were primitive by today's standards. News-gathering facilities beyond the local area depended upon telegraph and post. The art of photoengraving, still in the early stages of development, provided none of the pictorial presentation to which everyone has become accustomed in the press today. The printing process itself was a tedious matter in the absence of the high-speed rotary press. Newspaper circulation was limited both by this fact and by the lack of facilities for rapid distribution.

THE OPENING OF THE MODERN ERA

Thus, 75 years ago, the era of modern communication was just beginning. While the telegraph provided the first electrical communication as far back as 1844, the new age of rapid and extensive communication may be said to have opened in 1876 with the invention of the telephone. The founding of the ASME in 1880 coincided closely with the start of a long series of phenomenal scientific and engineering achievements making the United States into the wealthiest and most productive social unit ever known.

The limited means of communication available to the American of 1880 have evolved, largely at the hands of scientists and engineers, into a vast and efficient complex of telephone and telegraph facilities reaching to the remotest portions of the earth. The railroad, the only method of mass transportation in 1880, has undergone technological improvement in competition with two entirely new transport developments—the motor vehicle and the airplane. The printed page, which provided the only mass medium of communication in 1880, has experienced a major revolution with the engineering development of the rotary press and the introduction of high-speed photoengraving. And to all of these has been added a facility unknown in the world of 1880—the transmission of voice and sight by radio and television.

SPECIFIC CONTRIBUTIONS OF THE ENGINEER

The measure of the engineer's specific contribution to modern communications can be indicated almost by a random choice out of all the media to which everyone is now accustomed. Take, for example, today's complex of telegraph and wireless systems, descended in direct line from the cross-country wire and the telegraph key of 75 years ago. Almost the only vestige remaining of the ingenious but rudimentary system of 1880 is the use of code in the transmission of messages. The key has given way to the teletype machine with its perforated tape. The simple wire link has been expanded by multichannel circuits, and radio microwave channels capable of transmitting messages across country. Private teleprinter facilities automatically link business subscribers with a central telegraph office and thence with world-wide radio transmission facilities. These facilities provide customer-to-customer service between businessmen in the United States and many overseas countries. See Fig. 1.

A similar example exists in voice communication. This evolves from the rudimentary telephone system of 1880 (see title picture) through the development of radio into the intercontinental telephone network of today. The scattered local services of 1880 exist no longer. In their place stands an integrated nation-wide service involving more than 50 million telephones. This service is becoming automatic through the transition to dial systems in whose development the mechanical engineer has played a vital role. See Fig. 2 for the newly developed microphone-loudspeaker telephone. Augmenting this wide public service is a growing complex of commercial radio–telephone systems. In these systems, the telephone has been wedded to microwave radio relays to provide a highly effective means of voice communication among scattered installations or mobile units directed from a central office.

THE REVOLUTIONARY DEVELOPMENT OF SIGHT COMMUNICATION

These two examples—message and voice communication—are evolutionary in relation to the world of 1880. In the field of sight communication a completely revolution-

Courtesy Western Union Telegraph Company

Courtesy Bell Telephone Laboratories, Inc.

Fig. 1 (left). Newest wholly electronic and fully automatic facsimile equipment used in telegraphy. Fig. 2 (right). New distant-talking telephone which incorporates a sensitive microphone in its base and utilizes a loudspeaker, the small rectangle located on the right side of the desk

ary development is encountered. To the American of 1880, sight communication was limited to the range of the human eye, with only an occasional assist from an imperfect photograph taken and developed by processes that now appear archaic.

In contrast, the American of 1955 has been endowed with instantaneous sight across the continent by means of a television system. Television, which was practically nonexistent a few years ago and now reaches over 34 million sets, is beginning the era of color. At the same time the graphic arts, conveying visual information in more durable form, have experienced a phenomenal development in speed, quality, and quantity. The perfection of wirephoto and radiophoto, as well as the evolution of high-speed photoengraving and printing processes have resulted from this development.

The scientist and engineer, through the development of instruments for measuring and for the creation of terminology and standards, have added greatly to the communication of results in technology, industry, and commerce. To measure is to know—to know is to progress.

COMMUNICATION OF THE FUTURE

THE process of looking back 75 years before jumping to the present time leads inevitably into the complementary process of gazing an equal distance into the future. The directions in which we are headed are indicated clearly by recent discoveries which will take some time to bear their fruit. Even now, a number of trends are apparent. In all of these trends, the role of the engineer will be of constantly increasing importance because of the growing emphasis upon the development, arrangement, and use of complicated electronic, electric, and mechanical equipment. The most significant of these may be summarized as follows:

1. *Solid-State Devices.* Research in solid-state physics already has made available a fund of new knowledge and devices. These will alter basically the design and characteristics of electronic communications systems—increase their capabilities far beyond those employed today. These discoveries in the solid-state field promise to provide more precise control over many electronic processes.

New materials resulting from solid-state research already have been put to work in several areas. Among the most significant is germanium, which has made possible the development and the increasing use of transistors in basic electronic jobs that have previously been the province of the vacuum tube. There is also the development of new magnetic materials. The compact magnetic memory device, capable of storing large quantities of information for electronic computers and instantly "recalling" such information as and when it is required, is a result of this development. In the field of illumination, a variety of electroluminescent and photosensitive materials is finding application in new and more efficient types of lighting and in television.

From these new materials and techniques much may be expected in the way of improved performance. They will permit more compact design of electronic equip-

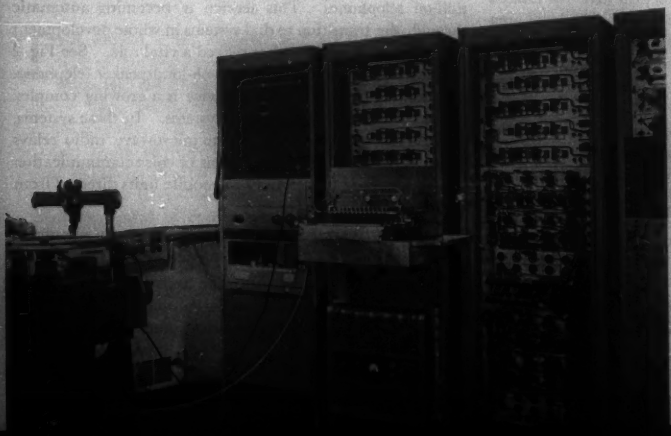


Fig. 3. RCA electronic music synthesizer showing the recorder, paper record drive, and half its electronic system

ment and greater economy of operation in a wide range of present communications devices. One result of particular interest will be an entirely new type of television receiver. Today's picture tube will be replaced by a thin screen hung in a picture frame on the wall and controlled from a small box elsewhere in the room.

2. *Advances in Personal Communication.* With the improvement of existing commercial communications systems and the development of new ones, a major advance in the field of personal communication is expected. Instantaneous contact between individuals anywhere in the country, and perhaps in the world, at any time and in any place is a definite possibility.

3. *More Efficient Use of Communications Channels.* Communications facilities today are crowding the air and existing wire systems. This in turn is leading to the renewed study of the fundamentals of communications theory and to the more efficient employment of available channels.

It is from greater understanding in communications theory that important advances may be expected. Through the coding of information, it is possible to do simply what otherwise might be too complex or too costly of communications channel width. In the future a telephone system will provide the party desired because the name or the number is spoken. A system can be expected which will type spoken words directly on paper. Also machines and systems will be developed which will do ones bidding in response to the spoken word. In reverse, from coded data, properly processed, the results can be reproduced in printed and even now in spoken form. A most recent example is the RCA music synthesizer—a new instrument of importance in future systems of communication. See Fig. 3.

4. *Data Handling Machines for Business and Industry.* Data handling machines, foreshadowed by the complicated electronic computers of today, will be adapted increasingly to a wide variety of business and industrial uses. They will assume many of the routine and repetitive functions of bookkeeping, inventory control, accounting, and inspection.

The application of electronic analyzing, data handling, and control mechanisms may be expected to reach far beyond clerical functions. These systems will develop to a point where they may analyze marketing and sales data, schedule production, order materials, control manufacturing processes, and schedule delivery of finished products. Already it is apparent that such systems can improve upon the performance of the human brain in repetitive thought processes, wherever data can be preanalyzed and stored in an electronic memory. See Fig. 4.

These future developments are ones that will be in service during the early portion of the next 75 years. Their roots are already apparent and their future growth can be expected with some certainty.

THE SCIENTIST–ENGINEER TEAM

BY TODAY'S STANDARDS, technology in 1880 was not complex. Basic scientific knowledge was limited. But now, specialization is a necessity in both science and engineering.

After 1900, scientists slowly began to be employed in industry. With the employment of scientists, industrial research had its birth. Science began to take on meaning and purpose in industry. Functional relationships between the scientists and the engineer, who was already established in industry, unfolded and team performance began.

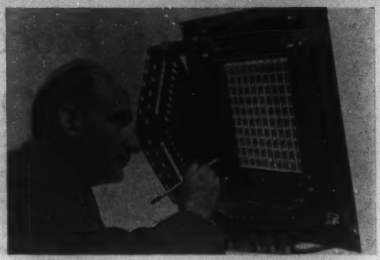


Fig. 4. RCA electronic high-speed memory stores or recalls data utilizing 10,000 tiny magnetic cores which "memorize" in a few millionths of a second

Now the roles of the scientist and the engineer are both established in industry. A full team relationship has developed. This is so much the case that the earlier clear-cut distinctions of function are not always recognized. A bridge has been formed between the scientist–engineer in industry and the scientist in the university. As a result, the application of scientific advances has been accelerated.

NEED FOR WIDER KNOWLEDGE

THE PURPOSE in reviewing the development of the scientist–engineer relationship is to set the stage for a further obligation. This is the necessity for both the scientist and the engineer to become familiar with, and to develop skills in areas broader than, the technology for which they are basically trained. The scientist–engineer relationship must be broadened to include the arts, the humanities, and politics. These will be the needs in the future in order that the scientist and engineer may discharge with competence their growing responsibilities.

FUTURE RESPONSIBILITIES

GIVEN the proper exercise of these responsibilities, there is no apparent limit to the technological progress and consequent prosperity and well-being that lie ahead. Already the development of swift and sure communications and transportation facilities have had a profound effect upon the world. Domestically, there has been a steady rise in industrial productivity and corporate efficiency aided by continually improving means of communication. In daily life, Americans have been brought into ever wider contact with their fellow men at home and abroad.

The advances made and the even greater ones to come in the varied spheres of communication can serve to promote greater harmony and understanding among all peoples. Increased communication can be a means to a oneness of spirit and purpose. In order that this might be achieved, we need to be sure that we and our systems and circuits of communication are attuned with, and include, the Creator of all. This, too, is good engineering.

Election Procedure for Institute Officers

L. F. HICKERNELL
CHAIRMAN, PLANNING AND CO-ORDINATION COMMITTEE

One of the functions of the AIEE Planning and Co-ordination Committee is to "consider and advise on all questions arising with reference to Institute activities of all types, particularly those in which uncertainty, difference of opinion . . . may appear to exist." It is to clarify the Institute's election procedure that this article was prepared.

ON or before April 15, all Corporate Members (Honorary Members, Fellows, Members, and Associate Members) will receive a ballot for election of a President, five Vice-Presidents, three Directors, and a Treasurer of the Institute, for the administrative year 1955–1956. Together with the immediate two Past Presidents, five Vice-Presidents (2-year term), and nine Directors (4-year term), these officers will form the new Board of Directors.

In the past when the mailed ballot has contained only the slate selected by the Nominating Committee, a few members have used their ballot to comment on the Institute election procedure.

The Planning and Co-ordination Committee has reviewed the election procedure and believes that it is as democratic and representative of the membership as any which can be devised, with due regard to efficiency and economy. However, as a result of its study, the Committee has concluded that the procedure is not universally understood by the membership and that probably this is due partially to the legal verbiage used to describe the procedure in the Constitution and Bylaws. Accordingly, this article has been prepared in an attempt to acquaint the membership with the procedure now in effect.

Fundamentally, the individual members nominate the candidates for national officers through a succession of delegations of voting powers. The chart on page 279 shows the method by which this is accomplished. Essentially, the Nominating Committee is composed of representatives from three primary sources, namely:

1. Sections
2. Technical Committees
3. Board of Directors

SECTION REPRESENTATIVES

BOTH Corporate and Noncorporate (Affiliate) Members are entitled to vote for Section Officers, consisting of a Chairman and Secretary and such other officers as provided in the Section Bylaws. These officers and others form the Section Executive Committee.

The Section Chairman and the one other officer, selected by the Section Executive Committee, represent the Section on the District Executive Committee, the Chairman of which is the Vice-President representing the geographical District on the Board of Directors.

The District Executive Committee acts as the Nominating Committee for the Vice-President. The national Nominating Committee merely includes in its ticket the candidates for Vice-Presidents, who have been named by the District Executive Committees, unless the latter have failed to act.

Each District Executive Committee elects each year a representative on the national Nominating Committee. Since there are ten Districts at present, there are ten District representatives on the Nominating Committee.

TECHNICAL COMMITTEE REPRESENTATIVES

AT present, the 40 Technical Committees and 200-odd Subcommittees are grouped into five Technical Divisions. The 2,000-odd personnel of these Committees are appointed by the President upon recommendations of incumbent Committee Chairmen, Division Chairmen, Vice-Presidents, Districts, Sections, or any individual member who chooses to volunteer the name and qualifications of a candidate.

A (Technical) Division Committee is composed of a Chairman, Vice-Chairman, Secretary, Chairmen of all Technical Committees in the Division, and members-at-large.

Each Division Committee elects each year a representative on the Institute Nominating Committee. Since there are five Divisions at present, there are five Division representatives on the Nominating Committee.

DIRECTORS' REPRESENTATIVES

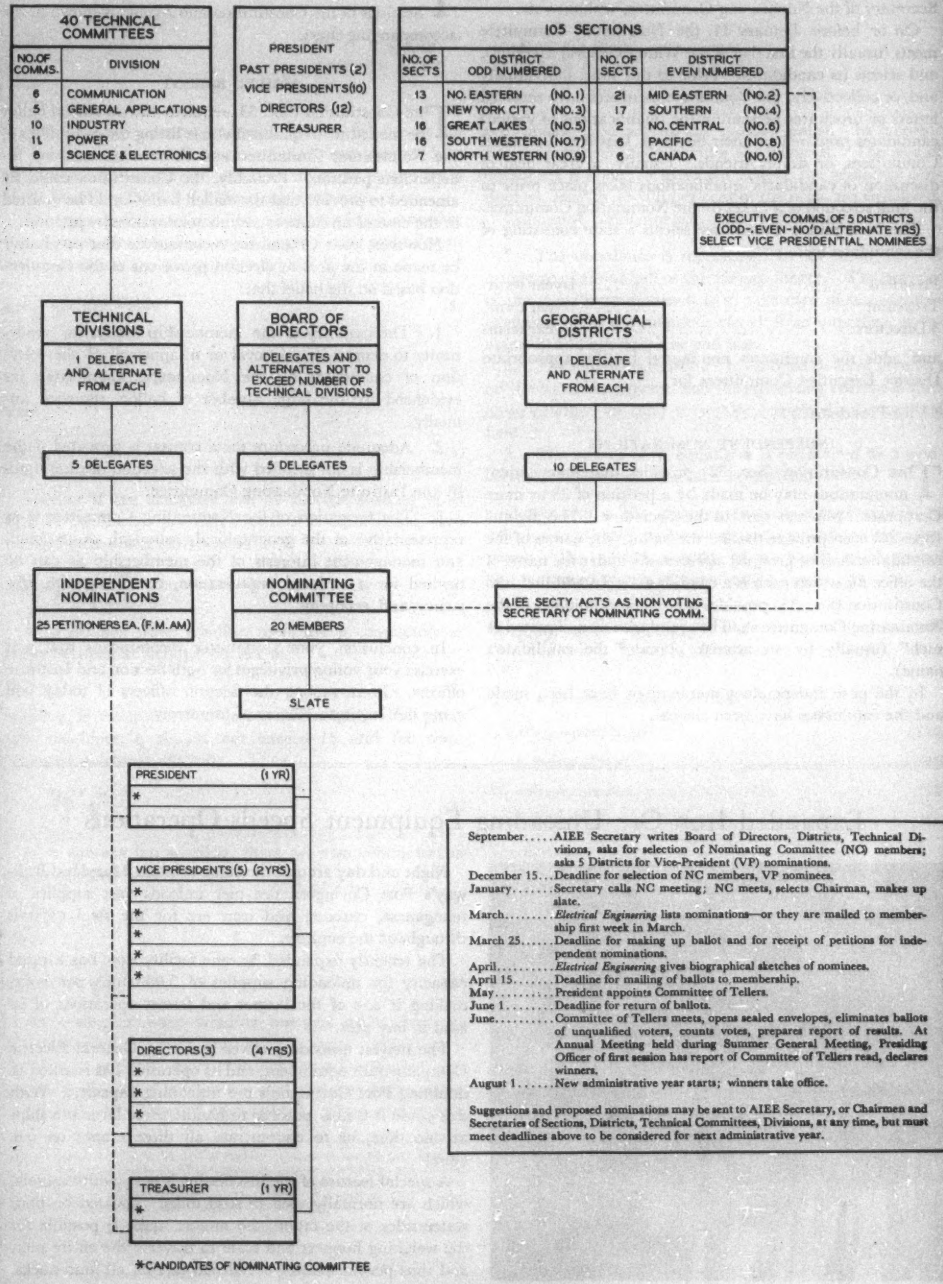
EACH year the Board of Directors elects representatives from its membership not to exceed the number of Technical Divisions (that is, five, at present).

NOMINATING COMMITTEE

ACCORDINGLY, the Institute Nominating Committee at present is composed of the following representatives:

10 from the Sections (through their representative Districts)
5 from the technical committees (through their representative Divisions)
5 from the Board of Directors
—
20—Total

AIEE Election Procedure



September	AIEE Secretary writes Board of Directors, Districts, Technical Divisions, asks for selection of Nominating Committee (NC) members; asks 5 Districts for Vice-President (VP) nominations.
December 15	Deadline for selection of NC members, VP nominees.
January	Secretary calls NC meeting; NC meets, selects Chairman, makes up slate.
March	*Electrical Engineering* lists nominations—or they are mailed to membership first week in March.
March 25	Deadline for making up ballot and for receipt of petitions for independent nominations.
April	*Electrical Engineering* gives biographical sketches of nominees.
April 15	Deadline for mailing of ballots to membership.
May	President appoints Committee of Tellers.
June 1	Deadline for return of ballots.
June	Committee of Tellers meets, opens sealed envelopes, eliminates ballots of unqualified voters, counts votes, prepares report of results. At Annual Meeting held during Summer General Meeting, Presiding Officer of first session has report of Committee of Tellers read, declares winners.
August 1	New administrative year starts; winners take office.

Suggestions and proposed nominations may be sent to AIEE Secretary, or Chairmen and Secretaries of Sections, Districts, Technical Committees, Divisions, at any time, but must meet deadlines above to be considered for next administrative year.

By December 15, the names of all these representatives must be in the office of the Institute Secretary, who acts as Secretary of the Nominating Committee, without vote.

On or before January 31, the Nominating Committee meets (usually the first day of the Winter General Meeting), and selects its candidates. Prior to this time, individually and/or collectively, the Committee members have received letters or brochures presenting the qualifications of various candidates prepared by their Sections, Districts, Technical Committees, or simply friends. Usually, a great deal of discussion of candidates' qualifications takes place prior to the final selection of a ticket by the Nominating Committee.

The Nominating Committee selects a slate consisting of the candidates for:

President	1-year term
Treasurer	1-year term
3 Directors	4-year terms

and adds the candidates nominated by the appropriate District Executive Committees for:

5 Vice-Presidents	2-year terms

INDEPENDENT NOMINATIONS

THE Constitution (Sec. 32) provides that independent nominations may be made by a petition of 25 or more Corporate Members sent to the Secretary. The Bylaws (Sec. 24) even provide that on the ballot "the names of the candidates shall be grouped *alphabetically* under the name of the office for which each is a candidate." In addition, the Constitution (Sec. 33) provides that "The candidates of the Nominating Committee shall be appropriately designated as such" (usually by an asterisk opposite the candidate's name).

In the past, independent nominations have been made and the candidates have been elected.

TIMETABLE

THE timetable for all these events established in various Sections of the Constitution and Bylaws is shown in the accompanying chart.

MAILED BALLOT

THE Constitution (Sec. 33) requires that an official ballot be mailed to all qualified voters listing the candidates of the Nominating Committee and those nominated by independent petition. Probably, the Constitution could be amended to provide that the mailed ballot could be omitted in the case of no contest; *i.e.*, no nominations by petition.

However, your Committee recommends that no change be made in the present election provisions of the Constitution based on the belief that:

1. The majority of the membership desires an opportunity to express its approval or disapproval of the selection of candidates by the Nominating Committee (as evidenced by the large number of ballots returned annually).
2. Adequate procedure for a contest is provided if the membership is not satisfied with the selection of candidates by the Institute Nominating Committee.
3. The formation of the Nominating Committee is as representative of the geographical, technical, professional, and management interests of the membership as can be devised for a national organization, consistent with efficiency and economy.

In conclusion, your Committee recommends that you exercise your voting privileges for both Section and Institute officers. From among the Section officers of today will come the Institute officers of tomorrow.

Expanded Iron Ore Unloading Equipment Speeds Operations

Night and day around the clock Western Maryland Railway's Port Covington ore pier unloads vast supplies of manganese, chrome, and iron ore for the steel capitals throughout the country.

The recently expanded 3-crane facility now has a rated capacity for unloading supplies of 3,000 tons per hour, making it one of the largest and fastest operations of its kind in any port.

The newest unloading tower is run by General Electric Company built equipment, and its operation has resulted in doubling Port Covington's ore unloading capacity. With this crane it is now possible to handle three large ore ships at one time, or to concentrate all three cranes on one vessel.

A special feature of the installation is heavy-duty motors, which are normally used in steel mills. Located on both water sides of the crane, the motors make it possible for the weighing hoppers and scale to traverse the entire pier, and thus permit loading of railroad cars on all four tracks.

Equalizer Section for D-C Armature Winding

T. C. TSAO
MEMBER AIEE

N. F. TSANG
MEMBER AIEE

WITH a given armature and fixed number of turns per coil, the voltage between adjacent commutator bars and the conductor current are both inversely proportional to the number of parallel paths in the armature.

The average induced emf of a conductor in an armature with p poles, diameter D, over-all length L, and operating at n rpm in an average air gap flux density B, is

$$e_c = \frac{n}{60} \pi DLB10^{-8} \text{ volts} \tag{1}$$

If

$$L = \lambda \times \text{pole pitch} = \lambda \pi D/p \tag{2}$$

then

$$\pi D = \sqrt{\frac{6 \times 10^8 p e_c}{\lambda B n}} \tag{3}$$

Further if the armature has an electric loading of Q ampere conductors per unit length of circumference, then the armature power (kw) will be

$$Kw_a = Q e_c^{1.5} \sqrt{\frac{6000 p}{PBn}} \tag{4}$$

In a simplex wave winding there are p conductors in series between adjacent bars, hence

$$p e_c = e_o \tag{5}$$

where e_o is the average voltage between bars. For interpole machines, e_o should not exceed 15 and for compensated machines, 20 volts. Thus

$$Kw_a = \frac{Q e_o^{1.5}}{p} \sqrt{\frac{6000}{\lambda B n}} \tag{6}$$

In a simplex lap winding, there are two conductors in series between bars, hence

$$2 e_c = e_o \tag{7}$$

and

$$Kw_a = Q e_o^{1.5} \sqrt{\frac{750 p}{\lambda B n}} \tag{8}$$

As a simplex wave winding has less paths than the corresponding lap winding, its slot space utilization is better. In addition, other objections to a lap winding are: more conductors of smaller size and therefore higher labor cost; and installation of equalizers to assure proper current distribution among the parallel paths. In conventional practice no definite rules are followed. The size of equalizers is about 25 to 50 per cent of the armature conductors, and 25 to 100 per cent of the coils are equalized.

Estimating conductor size consists of 3 steps:

1. The unbalance is represented by an eccentricity of armature of about half of the air gap length. The purpose of the equalizers discussed is to take care of unavoidable irregularities in the magnetic circuit from imperfect workmanship and normal wear and tear.
2. The equalizer resistance is assumed to have no effect on the equalizer current, and the equalizing current is such as to produce an mmf to restore completely the original field.
3. The system of T equalizers is considered as a symmetrical T-phase winding on a 2-pole basis.

Consequently, the above steps reduce the problem to calculation of magnetizing current of a polyphase induction motor. The maximum value of the 2-pole mmf caused by a balanced system of equalizing current i_{es} is

$$M = \frac{1}{\pi\sqrt{2}} N k_p k_d i_{es} \tag{9}$$

Now

$k_d = 1$ (approx.) = winding distribution factor

$$k_p = \mu P \pi / p = \text{pitch factor} \tag{10}$$

$$\mu = (p/P\pi) \sin (P\pi/p) \tag{11}$$

$$M_a = \text{max d-c armature reaction} = NI_c/(2p) \tag{12}$$

$$I_{es} = \sqrt{2} M p / N \mu P \tag{13}$$

The equalizer current is

$$i_e = 2 i_{es} \sin (\pi/T) = 2 i_{es}/T \text{ (approx.)} = \sqrt{2} \pi a I_c/(T \mu P) \tag{14}$$

where

$a = M_1/M_a = 0.4$ (approx.)

With the approximate values

$P = 1$, $\mu = 1$, $2\pi a/(\mu P) = 2$

$$i_e = 2 I_c / T \tag{15}$$

Thus with same current density, the total section of all equalizers in a simplex lap winding is equal to twice that of an armature conductor.

For an m-plex lap winding

$$i_e = 2 m I_c / T \tag{16}$$

The equalizer section for a d-c armature lap winding can be estimated by equation 16, which shows the total section of all equalizers is equal to twice that of an armature conductor times the multiplicity of the winding.

Digest of paper 54-367, "A Method of Finding Equalizer Section for D-C Armature Winding," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Published in AIEE *Transactions*, vol. 73, pt. III, 1954 (Jan. 1955 section), pp. 1586-89.

T. C. Tsao is with Ebasco International Corporation, New York, N. Y., and N. F. Tsang is with the University of Arkansas, Fayetteville, Ark.

The authors wish to thank J. G. Noest, Gordon Thompson, J. C. Aydelott, and M. Liwschetz-Garik for their advice and comment.

Electronic Pulse-Type Fault Locator Experience

R. L. BRINTON
MEMBER AIEE

Pulse-type fault analyzers are being used in greater numbers. Applications are not confined to power companies as oil companies now make use of them on their telephone lines. The installation of this type of instrument at most costs 10 per cent as much as the transient fault locator. Thus it can pay for itself as a result of a few outages.

At present there are two methods for locating faults on transmission lines. The more elaborate and expensive method is the transient fault locator which can find nonsustained faults. The pulse-type analyzer is relatively inexpensive and is successful chiefly in locating sustained transmission faults. The purpose of this article is to discuss pulse-type locators.

Use of the pulse-type electronic fault analyzer on power lines is not new. As the result of knowledge acquired from the development of radar during World War II, it was apparent that this principle could be applied to locating faults on transmission lines. The Ontario Hydro Commission[1] was one of the first operating organizations to develop and use such equipment on power lines. During the last 2 or 3 years, the use of this type of equipment has become widespread on the Pacific Coast. At least a half dozen power companies and government and municipal agencies are now using these instruments as a routine method for locating faults on power transmission lines and long-haul open-wire telephone lines. Such instruments have proven particularly useful on lines located in areas subject to heavy sleet, snow loading, and tree damage—especially in areas that are difficult to patrol.

PULSE-TYPE FAULT ANALYZER

At the present time, there is a number of manufacturers of pulse-type electronic fault locators. Some use a standard oscilloscope with the pulsing unit and sweep circuit enclosed in a separate cabinet; others assemble the entire instrument in one unit.

A typical instrument produced by a manufacturer in the San Francisco Bay area is shown in Fig. 1. This equipment is built on a production-line basis and is relatively low in cost compared with some of the first instruments which were

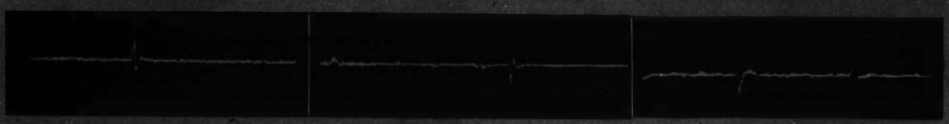


Fig. 1 (left). A typical electronic pulse-type fault locator. Fig. 2 (below left). A typical presentation of fault with sweep delay at 100 miles and sweep range of 25 miles. The pip two-fifths along the scale indicates a fault at 100 plus 10 miles. Fig. 3 (below center). The results of a test on a 60-kv line. Instrument on 100-mile sweep. The negative pip at 60 miles indicates the line is grounded at this point. Fig. 4 (below right). The results of a test on a 60-kv line. Instrument on 50-mile sweep. The positive pip at 17½ miles indicates one blade of the switch is open. This pip disappeared when the switch was completely closed

available. The instrument is comprised of a highly sensitive oscilloscope, a linear variable-sweep generator, and a pulse generator synchronized with the oscilloscope sweep. A 1,000-volt pulse of 1-microsecond width is applied at the start of the sweep. This pulse is formed by charging a condenser and discharging through a thyratron. If the fault is a short circuit or a ground or the impedance is lower than normal, the pulse reflection appears as a pip below the time base line. If the fault is an open circuit or the impedance is higher than normal, the reflection results in a pip above the base line. Distance presentation throughout is linear. The instrument is direct reading and requires no correction for open-wire high-voltage lines, where the velocity of propagation is approximately 98 per cent of the speed of light.

To assure utmost accuracy, all marker and sweep ranges are adjusted at the factory. A new flat-faced type *5ADP1* cathode-ray tube, together with the high pulse voltage of 1 kv and a sweep repetition rate of 120 cycles per second, provides the maximum in scope readability. A green filter further increases visibility and a mu-metal shield eliminates interference from external fields. A d-c post reflection potential of 3,200 volts is used to assure brilliant response from any point along the sweep, and an adjustable astigmatism control is used to minimize trace width.

The instrument is calibrated in ranges of 5, 25, 50, and 100 miles. For greater accuracy, a movable distance marker, formed in the time base, can be ranged from 5 to 100 miles. When the step is placed in coincidence with the fault, the distance is read directly from the dial. A sweep delay circuit is provided to extend the range of the instrument to 200 miles or to allow a small section of the line to be displayed for detailed study.

In the delayed sweep position, the display starts at the distance indicated by the marker dial and extends beyond this point for a distance determined by the sweep range switch. For example, assume a fault at 110 miles, a sweep range of 25 miles and the sweep delayed, the display is that segment of the line between 100 and 125 miles. The pip appearing two-fifths of the way along indicates a fault at a 110 miles (100 + 10). See Fig. 2.

OPERATING EXPERIENCE

The first tests of the performance of this particular instrument were conducted on the lines of the Pacific Gas and Electric Company and the Sierra Pacific Power Company which interconnect at the Donner Summit in the Sierra Nevada. In an initial experiment, the fault analyzer was connected onto a 60-kv line at a point 27 miles west of the summit. The line was grounded at a power house 60 miles away on the east side of Donner Summit. The analyzer not only located the grounded point within a half mile, but also indicated a change in configuration at 55 miles, a carrier coupling capacitor at 47½ miles, a substation tap at 37 miles, and a transformer bank and metering equipment at 27 miles, and switchyards at 17½ and 9½ miles. All appeared simultaneously on the 100-mile sweep presentation, and the pip below the line 60 miles indicated that the fault was either a short circuit or a ground. See Fig. 3.

Later, the same line was opened at the 60-mile point and the pip above the line indicated that the fault was an open switch. In further tests, the 60-kv line was opened at a sectionalizing point 17½ miles from the test point. Immediately, the instrument located the fault and identified it as an open circuit. See Fig. 4.

At the conclusion of the tests, the patrolman was instructed to close the switch. He shortly reported compliance with the instructions, but the analyzer indicated that the circuit was open at the same point. Several more attempts to close the switch followed, but the analyzer continued to show an open circuit. A line crew was called in, and upon close examination of the switch, found that one blade of the switch lacked complete closing by about an inch. When the linemen closed the switch blade, the analyzer then indicated that the line was closed through. If the line had been loaded in this condition, the blades could have been so severely damaged that it might have been necessary to replace the switch.

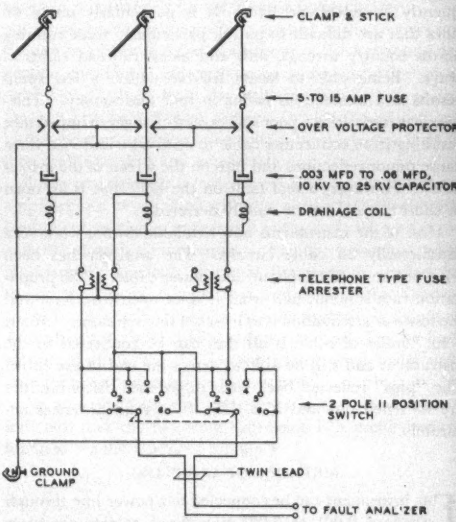

CLAMP & STICK
5 TO 15 AMP FUSE
OVER VOLTAGE PROTECTOR
.003 MFD TO .06 MFD, 10 KV TO 25 KV CAPACITOR
DRAINAGE COIL
TELEPHONE TYPE FUSE ARRESTER
2 POLE 11 POSITION SWITCH
GROUND CLAMP
TWIN LEAD
TO FAULT ANAL'ZER

Fig. 5. Diagram of a typical fault analyzer installation

During the past winter, the analyzer has been used frequently on 60-kv and 110-kv lines which run through very rough and mountainous country. In one case a broken conductor was located 77 miles away and in another case a fault was detected 110 miles away on a line 114 miles in length. This was found to be a broken conductor resulting from a tree falling on the line.

Last year the instrument was used on a telephone that was

Full text of a conference paper presented at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954 and recommended for publication by the AIEE Committee on Instruments and Measurements.

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in poor operating condition. Although it was possible to tell whether the end of the line was open or short circuited 7 miles away, also noted was a pip below the trace on the instrument several miles out which seemed to indicate a low-impedance point on the telephone circuit. By careful inspection of the line—at the point indicated on the fault locator—which ran through very rough and hilly terrain, this low-impedance point was located and proved to be one conductor lying on the crossarm with the tie wire almost touching the other conductor. When this condition was corrected, the telephone line operated normally, and the fault analyzer showed the line to be clear of reflections.

At the present time the analyzer is being used quite frequently on telephone lines. It is particularly useful on lines that are difficult to patrol, particularly those running across country through hills and along railroad rights of ways. Being able to locate trouble within a few spans results in a tremendous saving in time and money. Telephone transpositions, poor splices, and changes in impedance resulting from connecting cable to open wire and vice versa cause minor reflections and pips on the screen of the instrument. However, a real fault on the line, that is an open or short circuit, can be readily detected.

Most of the instruments now available do not work very satisfactorily on cable circuits. The analyzer has been tried out on both telephone and power cable. The propagation rate is about half what it is on open-wire lines and the losses or attenuation is at least ten times greater. About 5 to 7 miles of cable is all that can be connected to the instrument and still be able to detect the end of the cable. The "pips" reflected back from impedance discontinuities are flattened out and it is difficult to read distances accurately.

METHODS OF COUPLING

The instrument can be connected to a power line through standard 0.001 to 0.003-microfarad carrier capacitor coupling units. Otherwise, auxiliary capacitors, protected by high-current drainage coils, should be used. This is necessary since many power lines are parallel to each other, and even though the line may be dead, the induced voltage from the energized parallel line could be as high as 12,000 to 15,000 volts. When carrier coupling units are available, protection to personnel is no problem; since all connections can be made to the low side of the capacitor while it is grounded. When such equipment is not available and auxiliary equipment must be used, the faulted line should be cleared and grounded before connecting any of the auxiliary equipment. This auxiliary equipment consists of capacitors of varying sizes from 0.001 to 0.03 microfarad with a voltage rating of 10,000 to 25,000 kv and a 60-cycle drainage coil connected to 3 phases of the power line. It is good practice to insert a cone gap protector or equivalent that will arc over at 4,000 to 5,000 volts and to insert a 3- to 10-ampere fuse between the power line and the coupling capacitors. See Fig. 5 for typical installation. This should provide satisfactory protection for all personnel if they stay clear of the actual protective equipment when it is connected to the line.

When connecting the equipment to telephone lines, the aforementioned protection is not necessarily required. However, it is still good practice to insert at least a standard telephone fuse-protector block or coupling capacitors between the instrument and the line in order to provide some degree of protection to personnel and the instrument itself.

TRAINING OF PERSONNEL

One of the biggest problems in using this equipment is the training of personnel. The easiest way to get dependable results from the equipment is to have the equipment operated entirely by experienced electronic technicians. Since these men are limited in number and the equipment must be located in remote areas where these men are not readily available, it is necessary to train power house and substation operators to use the equipment. Many of these men have never operated standard television sets; consequently, it becomes quite a problem to instruct them in the use of an electronic fault analyzer which first entails the adjustment of the controls on a cathode-ray tube. A practical method of instruction is to take each line on which the instrument will eventually be used out of service, and run tests on it by opening and short circuiting the line at various points. In order that the personnel will not be confused with pips that would appear on the line normally, as a result of minor impedance irregularities, it is desirable to use a camera to take pictures of the line under normal conditions and with certain faults applied. These can later be reproduced and made available as a permanent record at the power house or substation for reference by the operating personnel when applying the equipment to the faulted line. Even though this is a great help, it is necessary to give the personnel additional instruction several times during the winter months when they may have occasion to use the equipment to insure that any actual fault readings will be properly interpreted.

This procedure may appear to be elaborate and at times expensive; however, if an operator at a power house or substation can localize the trouble on a 100- to 200-mile transmission line before the crews have started out to patrol for the trouble, the cost of the instrument can be recovered in one or two such outages. Many of these high-voltage lines may be worth several hundred dollars per hour and a 3- or 4-hour reduction in outage time on just one fault will practically pay for the cost of the instrument and its connecting apparatus.

CONCLUSION

The use of pulse-type fault analyzers is becoming more widespread. In addition to power companies, oil companies are now using them on their telephone lines. The installation of one of these instruments costs only 1/10 or 1/12 as much as the transient fault locator. Consequently, it is much easier to justify the installation of a pulse-type fault analyzer and prove that it will pay for itself on only a few outages.

REFERENCE

1. The Linascope Transmission Line Fault Locator, K. H. Kidd. AIEE *Transactions*, vol. 70, pt. II, 1951, pp. 1008–13.

Cyclic Integrator Measures Frequency Response

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THE time function most useful in applying a magnetic amplifier to a closed-loop control system is the frequency response characteristic. This describes the action of the amplifier in terms of amplification and phase shift of a sinusoidal control voltage, which is varied in frequency over some specified range. This digest describes the equipment and a technique that have been developed to measure these characteristics. An analytical expression for the transfer function of a full-wave self-saturating magnetic amplifier is proposed on the basis of experimental data.

Obtaining frequency response data for a magnetic amplifier is complicated by its pulsating variable-waveform output voltage. Interpreting such a voltage is difficult, since the waveform peak value is not a measure of its average value. The component of output voltage having control-signal frequency must be extracted from this waveform, and the gain and phase shift between it and the control signal determined. The average value of output voltage is the quantity usually of prime interest because most electric control elements are linearly responsive to their average input voltage.

An electronic measurement device, called a cyclic integrator, has been developed which transforms the magnetic amplifier's output-voltage waveform to a different waveform that can be easily interpreted. The cyclic integrator generates a narrow pulse of voltage during each half-cycle of the power supply voltage. The magnitude of each pulse is proportional to the average value of the magnetic amplifier's output voltage for the half-cycle period preceding the pulse. The equipment and measurement method can be used with any magnetic amplifier circuit that produces an output voltage which is a rectified sine wave with only the leading part of each pulsation being varied to control the output.

The block diagram of the system is shown in Fig. 1. An electronic ultra-low-frequency oscillator is used to generate a signal voltage which is amplified by a direct-coupled power amplifier. The output of the power amplifier drives a signal winding on the magnetic amplifier through an attenuator, resulting in an output which is modulated at the signal frequency. The output voltage from the magnetic amplifier is applied to the cyclic integrator and thereby transformed to a waveform of pulses, the amplitude of which varies in accordance with the average output voltage. The output of the cyclic integrator is applied to the vertical deflection amplifier of a d-c oscilloscope. The horizontal deflection amplifier of the oscilloscope is driven by the sinusoidal signal voltage from the oscillator after it has passed through a calibrated phase shifter. Driving the oscilloscope in this manner produces a lissajous pattern which is used to indicate phase shift and amplification.

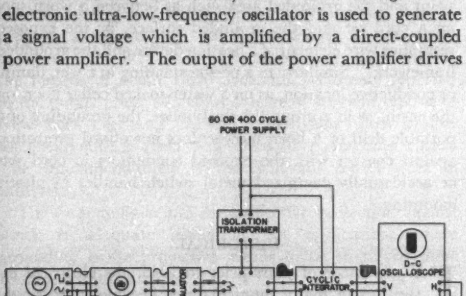

Fig. 1. Block diagram for cyclic integrator equipment

Points on a frequency-response curve for a given magnetic amplifier can be obtained with this system by adjusting the equipment to give a trapezoidal pattern of constant shape and size at each signal frequency over the frequency range of interest. Readings of signal frequency in cycles per second, amplification in decibels, and phase shift in degrees, constitute the desired frequency-response data. It should be re-emphasized that all of the data are read directly from calibrated dials, the oscilloscope presentation being used only for maintaining a constant pattern.

An analysis of response data taken in the above manner indicates that the following expression is a useful transfer function for the magnetic amplifier

$$\frac{E_o}{E_s} = \frac{K\epsilon^{-j\frac{\omega_s}{\omega_c}\alpha_{av}}}{\left(1+j\omega_s\frac{L_s}{R_s}\right)}$$

where

K = a constant
$f_s = \omega_s/2\pi$ = signal frequency
$f_c = \omega_c/2\pi$ = carrier frequency
α_{av} = the average firing angle, radians
E_o = the output voltage change (a signal frequency sinusoid)
E_s = the input voltage producing the change (a sinusoid)

The equation consists of a term in the denominator which is associated with the normal inductance-resistance signal-circuit time constant and a term in the numerator which is called the "transportation lag." The agreement of analytical and experimental results indicates the usefulness of the transfer function derived in the paper.

Digest of paper 54-260, "The Cyclic Integrator—A Device for Measuring the Frequency of Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Published in AIEE *Communication and Electronics*, September 1954, pp. 358–65.

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The development and experimental work covered in the paper was performed at the General Engineering Laboratory, General Electric Company, Schenectady, N.Y. The assistance of G. C. Dodson and L. R. Pangburn in the preparation of the paper is greatly appreciated.

Grounding of Portable Electric Equipment

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MEMBER AIEE

The new requirements affecting the use of portable electric equipment in the National Electrical Code, 1953 revision, are presented and discussed. Portable appliances, tools, and lighting equipment are included.

IN the 1953 revision of the National Electrical Code (NEC), new requirements were included for grounding and for the devices to be used in making the grounding connections. The purpose of this article is to record and discuss this step in the use of portable electric equipment. The products involved in the discussion are the portable appliances, portable tools, and portable lighting equipment designed for use on the 120-volt 2-wire or 120/240-volt single-phase 3-wire grounded neutral branch circuits required for general purpose interior wiring in Article 210 of the NEC.

"Grounding" as used here denotes the use of a reliable electric conductor installed for the purpose of electrically connecting the exposed noncurrent carrying metal parts of a portable equipment to the same grounding electrode to which the grounded neutral of the interior wiring system is connected at the service entrance.

"Portable electric equipment" as used here denotes any appliance, tool, lamp, toy, or other equipment incorporating one or more electric power utilizing components where established practice or conditions of use make it necessary or convenient for the equipment to be attached to the source of current by a flexible cord and attachment plug. The portable may be basically an electric powered equipment as in the case of an electric flat iron or a portable electric drill, or it may be an equipment in which the electric component is of secondary importance as in the case of a grocery store scale with an illuminated dial.

CONDITIONS ASSOCIATED WITH SHOCK

PORTABLE EQUIPMENTS are required to be grounded to maintain the potential on exposed noncurrent-carrying metal parts of the portable at ground potential for the purpose of eliminating shock hazard. Insulation, isolation, and guarding are alternative means which may be used for the prevention of shock. This article contains no discussion of threshold, let-go, or lethal currents, or of paths through the body.

The conditions necessary for shock to occur include a circuit through the body between two points at a difference of potential. These two points may be

1. Points on each of two circuit conductors at full circuit potential difference.
2. An ungrounded circuit-conductor and an effective return through a person to ground.
3. Exposed noncurrent-carrying metal parts accidentally energized to full or partial potential by insulation failure and an effective return through a person to ground.
4. Contact between intentionally grounded exposed metal parts and other points which are at full or partial circuit potential above ground.

Grounding of the exposed metal parts of a portable through a low-resistance grounding circuit will afford effective protection against shock when an insulation failure within the equipment connects an ungrounded circuit conductor to the grounded metal by causing the branch-circuit overcurrent device to operate. Under any other type of abnormality in the use and handling of a portable with grounded surfaces, these grounded areas provide the return path to ground for any contact made between a live point and the grounded area such as between a worn spot on a cord set and the grounded surface, or the exposed resistance wire element of a heating device and the grounded framework. Similarly to a person standing in a wet, damp, or conductive location, as on a water-soaked cellar floor, on the earth, or in a grounded steel boiler, the grounding of a portable drill or a lawn mower does not afford protection against contact with the exposed conductors in cord sets or accidentally energized metal switch handles in plastic mounting.

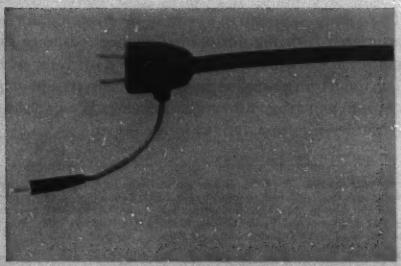


Fig. 1. 15-ampere 125-volt attachment plug and flexible cord with "pigtail" grounding lead prohibited after January 1, 1955

HISTORICAL

FOR a number of years prior to 1945, the electrical inspectors of many municipalities became increasingly alarmed at the growing number of electrical accidents in the

Full text of a conference paper presented at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954, and recommended for publication by the AIEE Committee on Safety.

L. S. Inskip, chairman of the NEC Code Making Panel No. 5, is with Bell Telphon Laboratories, Inc., Murray Hill, N. J. and H. H. Watson, chairman of NEC Code Making Panel No. 2, is with the General Electric Company, Bridgeport, Conn.

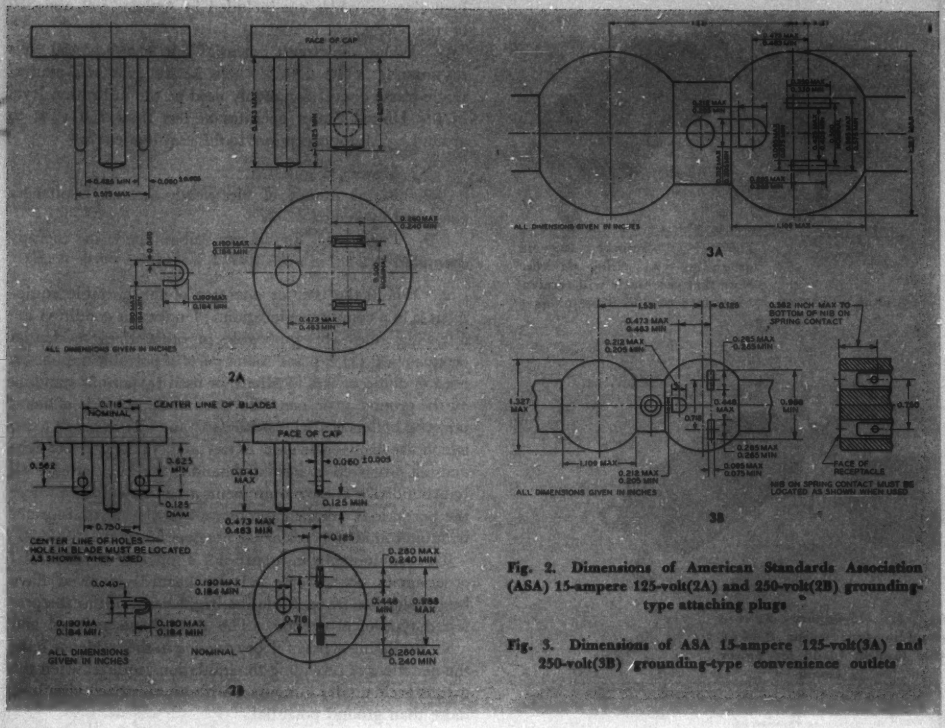

FACE OF CAP
ALL DIMENSIONS GIVEN IN INCHES
2A
CENTER LINE OF BLADES
NOMINAL
FACE OF CAP
CENTER LINE OF HOLES
HOLE IN BLADE MUST BE LOCATED AS SHOWN WHEN USED
ALL DIMENSIONS GIVEN IN INCHES
NOMINAL
2B
ALL DIMENSIONS GIVEN IN INCHES
3A
ALL DIMENSIONS GIVEN IN INCHES
0.562 INCH MAX TO BOTTOM OF NIB ON SPRING CONTACT
FACE OF RECEPTACLE
NIB ON SPRING CONTACT MUST BE LOCATED AS SHOWN WHEN USED
3B

Fig. 2. Dimensions of American Standards Association (ASA) 15-ampere 125-volt(2A) and 250-volt(2B) grounding-type attaching plugs

Fig. 3. Dimensions of ASA 15-ampere 125-volt(3A) and 250-volt(3B) grounding-type convenience outlets

use of portable electric equipment of all kinds. At the October 1945 meeting of the Electrical Committee* of The National Fire Protection Association, Alvah Small, chairman, took cognizance of the situation and delegated the Article 250 Committee under the chairmanship of A. H. Schirmer, then of Bell Telephone Laboratories, Inc., to prepare a report with recommendations for necessary changes in the NEC. Mr. Schirmer's committee studied the records of about 1,000 accidents accurately reported in the public press, as well as 5 years of accident reports of New York City and California, analyzing them against the background of grounding versus other protective means. The recommendations of the Schirmer report were in substance.

The most reliable and most effective protection against shock is adequate insulation. In applications where grounding is the protective means to be employed these recommendations apply:

1. Portable tools with exposed metal parts used in wet or conductive locations shall be provided with a grounding conductor in the power cord.

2. Separate grounding conductors shall require special permission.

3. All conductors in the power cord shall terminate in blades in the attachment plug.

4. New wiring devices shall be provided which will accommodate the grounding circuit in terminals and connecting means which are readily distinguishable from the power circuit members.

5. The proposed 3-pole 15-ampere 125-volt grounding receptacle shall also receive the present parallel blade attachment plug.

6. The proposed plugs and receptacles shall be so designed as to prevent contact of the grounding blade with live female contacts.

At the January 1947 Winter Meeting of the American Institute of Electrical Engineers in New York the Committee on Safety conducted a full-day symposium at which 25 speakers representing 25 viewpoints discussed many aspects of the problem of grounding portable equipment. The consensus developed by the Committee on Safety at this time was a full endorsement of the principles set forth in the Schirmer report.

Finally in 1953, after a number of years of most careful consideration, these established principles were reduced to workable NEC requirements and incorporated in the 1953 revision of the NEC.

*Now superseded by the NEC Committee composed of the NEC Correlating Committee and 18 Code Making Panels.

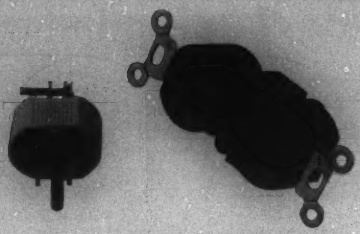


Fig. 4. 15-ampere 125-volt grounding-type wiring devices. Note that receptacle will receive standard parallel-blade plugs

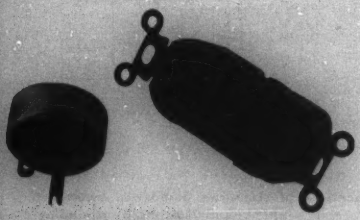


Fig. 5. 15-ampere 250-volt grounding-type wiring devices. Note tandem blade for power circuit

NEC REQUIREMENTS

SECTION 2545 NEC† requires that the exposed noncurrent-carrying metal parts of portable equipments shall be grounded under any of these several conditions:

a. Where equipments are used in hazardous locations. ("Hazardous locations" are accurately defined in the NEC and specific requirements for the use of electric equipment including portables are included in Articles 500 and 510 of the Code.)

b. Where the circuit potential is in excess of 150 volts to ground. (The 120/240-volt 3-wire grounded-neutral single-phase circuit commonly used at the utilization level in the United States operates at less than 150 volts to ground.) Minor exceptions to this requirement are

1. Motors, if guarded.
2. Metal frames of electrically heated appliances exempted by section 4238.
3. Enclosures for X-ray tubes used in therapy exempted by section 6633.

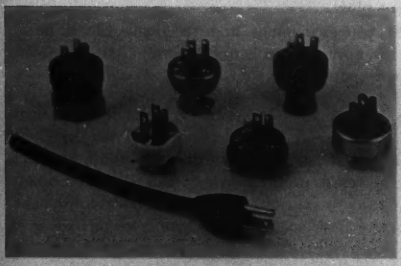
c. Where the user or operator of the portable equipment is in a conductive location. Under this condition the following rules are applicable in other than residential occupancies: (1) exposed metal parts of portable appliances used in damp or wet locations, or used by persons standing on the ground or on metal floors or working inside of metal tanks or boilers shall be grounded; and (2) portable tools, which are likely to be used in wet and conductive locations and not protected by insulated handles and enclosures, shall be grounded. These requirements are not applicable where the portable is supplied through an insulating transformer with ungrounded secondary of not over 50 volts.

The requirements in (c) are not applicable to residential occupancies because the relative hazards involved have been judged to favor insulation in the residence as the preferred type of protection. The general use of wood and other insulating types of floor covering in the residence have the net effect of providing the insulation required when the user is accidentally in contact with an energized circuit at more than ground potential.

In Section 2559 NEC are delineated the three means which may be employed for grounding the portable. These are:

1. By means of a grounding conductor included with the circuit conductors of the flexible cord and suitable attachment plug and receptacle combination for establishing a

† All references made to the NEC in this section are to the 1953 edition.



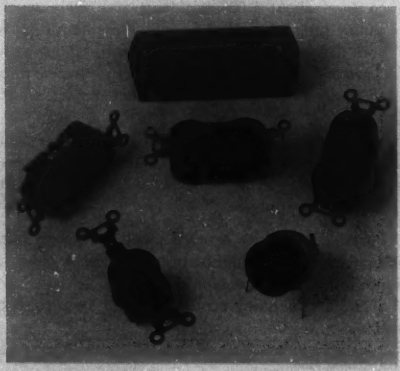


Fig. 6 (above). 15-ampere 125-volt grounding-type attaching plugs. Fig. 7 (right). 15-ampere 125-volt grounding-type convenience outlets. Note the device is available as a flush outlet, a surface outlet, as a cord connector body, and in single and twin arrangements

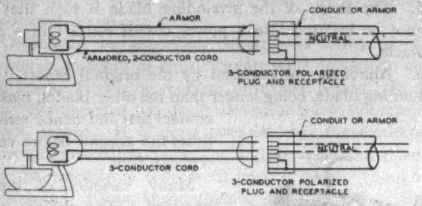


Fig. 8. Some recognized methods of grounding portables

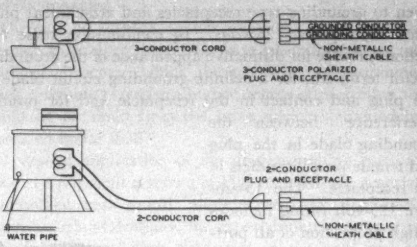


Fig. 9. Some recognized methods of grounding portables

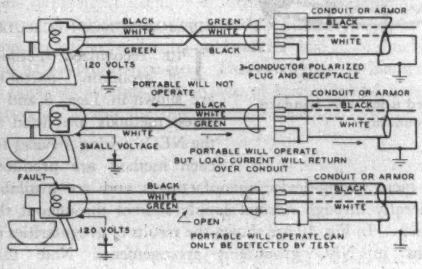


Fig. 10. Conventional grounding—effect of irregularities

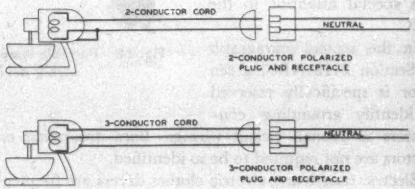


Fig. 11. Grounding portables by connection to the neutral conductor

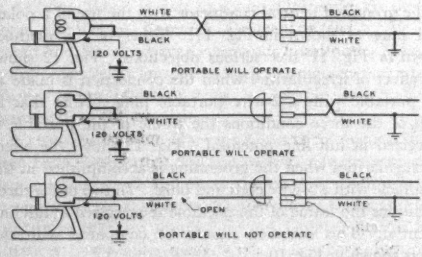


Fig. 12. Bond to neutral conductor at portable—effect of irregularities

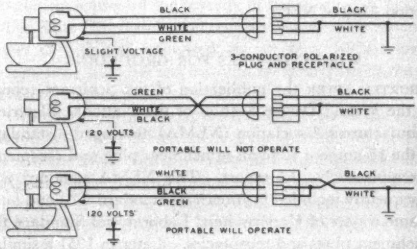


Fig. 13. Bond to neutral at receptacle—effect of irregularities

ground connection to the same electrode as used for the system ground at the service entrance.

2. Provision as in (1) except that the armor or metal enclosure of the circuit conductors may be used as the grounding conductor.

3. A separate grounding conductor, as a bare or insulated flexible wire or strap not in the supply cord, may be used only when part of an approved equipment or by special permission of the enforcing authority.

In (1) and (2) of the preceding, the NEC further requires that the attachment plug include one fixed contacting member for the purpose of establishing the grounding circuit.

Section 4010 NEC is a cross reference requiring that when a flexible cord is supplied with a grounding conductor the attachment plug must comply with the provisions of Sections 2559a and 2559b previously outlined. The net effect of this requirement is to outlaw the pigtail type of grounding connection shown in Fig. 1. In order to allow manufacturers and others to properly prepare their inventories for this requirement the effective date has been set at January 1, 1955.

In Sections 4164 and 4165 NEC special attention is given to grounding-type receptacles and attachment plugs rated 15 amperes, 125 volts. In combination these two sections provide for distinctive appearance of the grounding circuit terminals, for a definite grounding circuit blade in the plug and contact in the receptacle and for positive interference between the grounding blade in the plug and female power contacts in the receptacle. The 15-ampere 125-volt rating includes a high proportion of all portable equipment ratings where the connection is to a general-purpose branch circuit; hence the rating merits this special attention in the NEC.

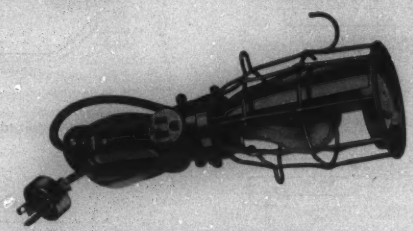


Fig. 14. Portable lamp and guard using ASA standard wiring devices for grounding

In the second paragraph of Section 2112 NEC, green color is specifically reserved to identify grounding conductors in branch circuit wiring. Bare grounding conductors are not required to be so identified.

Electric ranges and electric clothes dryers are frequently connected to their branch circuits by attachment plugs and flexible cords. These two appliances are the only exceptions to the general rule that grounding must not be accomplished by connection to a grounded circuit conductor at the appliance. This permissive requirement is found in Section 2560 of NEC.

WIRING DEVICES FOR GROUNDING

SHORTLY AFTER the publication of the Schirmer report, the Wiring Device Section of the National Electrical Manufacturers Association (NEMA) developed a standard for the 15-ampere 125-volt attachment plug and receptacle contemplated by the report. This NEMA standard was subsequently included in American Standard-C73 and later became a part of Underwriters' Laboratories Standard for attachment plugs and receptacles. Later in 1951 a similar standard was developed for 15-ampere 250-volt devices. The dimensions for the attachment plugs are shown in Fig. 2. The dimensions for the convenience outlet are in Fig. 3. Figs. 4 and 5 show typical devices.

These wiring devices accomplish the objective of the Schirmer report in the following respects:

1. The grounding conductor is contiguous with the power conductors of the supply cord.

2. A blade in the attachment plug is provided for the grounding conductor. A mating contact is included in the receptacle.

3. The binding screws or other terminating means provided for the grounding circuit conductors are distinctively marked to be readily distinguishable from the power conductors.

4. The parallel blade 15-ampere 125-volt standard attachment plug can be used with the 125-volt 15-ampere grounding receptacle since the power contact slots and power contacts are the same for both types of receptacles.

5. The shape of the grounding blade is such that it cannot be inserted into a power circuit contact in a receptacle.

6. Although not required by the original report, the grounding blade, being longer than the other blades, makes contact first and hence establishes the ground before current can flow.

Many varieties of these standard wiring devices are available from the manufacturers of wiring devices as shown in Figs. 6 and 7.

APPLICATION OF NEC RULES

THE recognized methods of grounding portables are shown in Figs. 8 and 9. These methods are listed in the NEC; wiring devices for each method are produced by most wiring-device manufacturers and are available generally through normal supply sources throughout the nation. In Fig. 10 are shown the results of irregularities or faults in NEC grounding arrangements. Note that normal performance of the appliance cannot be relied upon as a check on the existence of the ground.

The suggestion is frequently made that grounding could be accomplished by connection of the frame of the portable to the grounded neutral conductor with the use of a polarized plug as shown in Fig. 11. Either of the methods shown in Fig. 11 has serious objections. Fig. 12 shows the effect of irregularities when the connection is made at the portable with a 2-wire portable plug. Note that in each of the three conditions the frame of the portable is energized at full line potential. Fig. 13 shows the effect of irregularities when the grounding is accomplished in the receptacle with a 3-wire cord and plug. In two of the three conditions the frame of the portable is energized at full line potential. This situation should be compared with the effects shown in Fig. 10.

For residential occupancies the Code does not require that metallic enclosures of portable equipment be grounded. It does require portables to be grounded in other than residential occupancies if used in wet or damp locations or by persons standing on the ground, metal floors, or the like.

As a result of some fatal accidents in homes, there has been agitation to ground the metallic enclosures of all portable equipment including those used in residential occupancies. Whether such a rule would materially reduce the accidents is questionable. A high percentage of accidents from ordinary house voltages are due to the use of substandard or homemade equipment, poor maintenance, and improper connection and use of equipment. Very few if any of such accidents would be prevented by a grounding requirement in the Code.

There are definite limitations to grounding as a safety measure, particularly in the area within the scope of this article. There is no evidence of the loss of grounding

connection except by tests. These tests require the use of instruments or other means not ordinarily available to residential occupants.

Ordinarily the grounding circuit is of sufficiently low resistance to result in fault currents large enough to open the branch circuit overcurrent protective means. In this case high-impedance faults in the device would not result in shock hazard. It is quite essential that the equipment enclosure grounding connection and the means for grounding the raceway to the circuit neutral be low enough in resistance to assure de-energization of the faulted condition as well as to limit the potential to ground.

For the grounding of portable equipments, the addition of a third conductor in the cord set is required. The possibility of incorrect assembly or incorrect reconnection at the time of making repairs introduces a hazard judged to be more serious in residential occupancies than in commercial and industrial occupancies. This is because the likelihood of poor workmanship or a lack of knowledge of how to properly connect the three wires is more likely to be encountered in the residential than in commercial or industrial occupancies.

There is no dispute among individuals who have had occasion to analyze the problems of grounding that a well-insulated device in which the possibility of sustaining a shock is remote provides a higher degree of protection than would be obtained from the same device contained in a grounded metal shell.

A typical application of the new grounding rules to a piece of equipment is shown in Fig. 14. Here, in a portable lampholder and guard manufactured by the McGill Manufacturing Company, the exposed metal parts are connected to a grounding conductor in the cord and to a standard grounding-type attachment plug. A receptacle for circuit extension purposes is correctly supplied with grounding-type contacts.

REFERENCE

1. Safety Aspects of Grounding Portable Equipment, **H. B. Whitaker**, *Electrical Engineering*, October 1952, pp. 897–902.

Weather Radar Installed on Hilltop in Massachusetts

A special weather radar that can watch storms miles away from Boston has been installed atop Great Blue Hill in Milton, Mass., it was announced recently by the Air Force Cambridge Research Center (AFCRC), Air Research and Development Command, Cambridge, Mass.

Built specifically for meteorological purposes, the radar—known as an *AN/CPS-9*—is a versatile and valuable weather-detection instrument.

Meteorologists from Harvard University assigned to the Blue Hills Observatory will use the radar to determine the size, intensity, and sometimes the direction and speed of movement of squalls, fronts, thunderstorms, hurricanes, and rain areas that are moving toward Greater Boston from distances many miles away.

The Harvard scientists will operate the weather radar under a research contract with the AFCRC.

The new radar is for research purposes only, and cannot function as a weather warning station; therefore, information on approaching storms will not be given out to the public.

The *AN/CPS-9* allows a meteorologist to scan in either a vertical or horizontal plane. Through vertical scanning the heights of a cloud top, the base, and the freezing level can be determined much earlier than was possible before.

Even the size of particles of precipitation can now be discovered, and the changes in these particles as they grow or evaporate can be measured.

In continuous-type precipitation, such as snow or rain storms, the nature of the particle-generating cells can be studied in detail through use of the new versatile and sensitive apparatus.

Additional uses of the radar, according to the scientists, will be in vertical scanning of thunderstorm formations to aid in mapping regions of updrafts and downdrafts to give a better indication of the severity of the storm.

The Blue Hill installation consists of a rotating antenna, 8 feet in diameter, mounted on top of a 50-foot tower. A Jamesway hut, 300 feet away in the courtyard of the observatory, contains the console.

This console, which controls the operation of the radar, has four scopes for presentation of the information received. An *A* scope shows signal intensity as compared with range; an RHI (range-height indication) scope allows views of the storm in vertical cross section; a normal PPI (plan position indication) scope presents weather echoes in the form of a map, with the radar at the center; and an off-center PPI scope allows additional coverage.

There is also a "slave" PPI scope located in the observers' room within the observatory.

From now on, information on normal storms approaching this area, as well as possible hurricanes similar to "Carol" and "Edna," will be accurately recorded while the disturbances are many miles away. Normal range is expected to be between 200 and 300 miles, with a maximum range of 400 miles. Scientists do not expect to receive precipitation echoes beyond 300 miles, however.

The equipment was installed through the co-operation of a radar installation team from an Air Force Depot in Rome, N. Y., the Air Installations Office of AFCRC, and the personnel of the Blue Hill Observatory.

Information obtained from the newly installed radar set will be studied by the Atmospheric Physics Laboratory of the Geophysics Research Directorate, AFCRC, at Cambridge.

Possible Energy Trends

D. P. BARNARD

The future of nuclear energy is of great interest. It is appraised here as to its "probable position" in the "foreseeable future" as compared with conventional power sources.

THE ENERGY from nuclear reactions makes its appearance mainly as heat. The heat portion only can be used—in the light of present know-how—for the production of power or for any other "constructive" purpose. Heat is merely one form of energy and, therefore, carries with it the implication that it can be transformed into any other required energy form. However, many prolific sources of heat are economically unusable with present technology. For example, an enormous amount of heat energy is stored up in the sea, but its temperature level is so low that it cannot be profitably employed—at least at present. The same is essentially true of tide, wind, and low-head hydraulic energy sources. Even solar energy, while generated in fantastic amounts and at extremely high temperature levels, is economically unsuitable for serious power production or for direct use as a heat source. From a practical standpoint, forms of heat must be sought which can be converted into other types of energy on a convenient and an economically attractive basis.

POSSIBLE FUTURE FOR NUCLEAR FUELS

PUTNAM, in his book entitled "Energy in the Future," cites a number of competent opinions on the possible future for nuclear fuels.[1] Although they are several years old, a few of these are of interest at this time. "... the total available supply [of uranium] is seriously limited ..." (Smyth, 1945)

"We see no real limitation on the availability of nuclear fuel. Therefore we may look forward to the widespread application of such sources of power to the future economy and technology of the world." (Oppenheimer, 1947)

"It appears clear that atomic energy is on a sound basis for an indefinite period in the future." (Lilienthal, 1948)

"Simon (1949) does not expect atomic energy to contribute an appreciable part of our total power within the next 50 years or so."

"The first and experimental phase of the atomic energy program will take from 3 to 5 years. In 3 to 5 years after that, we may have a reactor producing electric power. Four or 5 years later, we may have some commercial generation of nuclear power." (Sporn, 1949)

"There is good probability that nuclear power for special purposes could be developed within 10 years..." (Kramer, 1949, quoting Professor H. D. Smyth)

"We are forced to the conclusion that even if all of the technological stumbling blocks are removed, nuclear power will be sure to cost a great deal more than power from hydroelectric plants or from steam plants with fuel costs many times what they are now." (Ayres, 1950)

"In short, not only is a general relocation of industry unlikely to follow the introduction of commercial atomic power at competitive prices, but the likelihood of the introduction of such power at costs which are as low as those of the better conventional fuel and power sources is itself a moot question." (Isard and Whitney, 1950)

"Industrial development in many regions of the earth which have necessary raw materials, but no available power, can be expected." (Perlman, 1946)

"A large-scale application of nuclear power plants might well mean the industrial development of parts of the world where conventional fuels or hydroelectric power are not readily available." (Wiggins, 1947)

"Atomic power may not prove to be much of a boon to partially developed regions remote from fuel sources." (Isard and Lansing, 1949)

WHY "MAN-MADE" NUCLEAR ENERGY?

JUST WHY is there such intense interest in "man-made" nuclear energy at this time when, after all, the sun is a nuclear reactor producing energy on a vast scale? It has been estimated that the total amount of solar energy striking a 5° band of the earth's surface each 24 hours at the equator is roughly equivalent to that released by 1,000,000 Hiroshima-type atomic bombs. Perhaps the total amount of energy reaching the earth's surface, therefore, would be much greater. With such enormous amounts of energy coming to us free, and due to continue for countless millenniums, it would seem that we should be willing to go to considerable lengths to capture substantial quantities of such energy. The troubles with the solar energy picture are

1. It arrives at the earth's surface at a comparatively low level of temperature or radiation intensity.
2. It is not continuously or reliably available (particularly in the more heavily populated latitudes).
3. Since there is no control over its availability, it would either have to be captured in large quantities for storage until needed, or supported with stand-by artificial power generation. As everyone knows, either procedure is out of economic reach.

Advantages and Disadvantages. In essence, the nuclear reactor has been looked upon as a sort of "private sun" which is not subject to the drawbacks of solar energy. While this is essentially true, artificial nuclear-energy generation has its own practical limitations—at least within the

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limits of current know-how. The most readily usable form is that in which the nuclear reactor replaces the conventional fire box as a source of heat. From there on, the system becomes reasonably conventional, although for reasons peculiar to nuclear processes, certain additional problems must be recognized. The net result is that, in addition to the bulk and weight of a conventional steam plant, for example, we must paint into the picture requirements for radiation shielding and other unique provisions which make the entire installation bulkier and much heavier than a conventional plant of given output.

A good picture of the pros and cons of nuclear-power generation can be obtained by comparing a nuclear-power plant with a conventional steam plant. The main difference will be in the heat source itself and, as usual, there must be some trading of advantages and disadvantages. Nuclear generation essentially eliminates fuel transport and storage but, in return, imposes the need for the expensive, somewhat bulky, and (with its shielding) considerable reactor weight. Fuel costs for nuclear energy are not negligible. It has been frequently imagined that, once a nuclear source is put to work, it goes on forever much as the sun itself appears to do. This is not true, and the life of any nuclear fuel is definitely limited and must be replaced just as coal or any other conventional fuel. While the bulk and weight of nuclear fuel that must be handled is negligible in comparison with conventional fuels, the costs are not. As a matter of fact, nuclear fuel costs are likely to exceed the cost of more conventional fuels for some time to come. The radiation problems associated with the use of nuclear fuels are widely recognized to be serious. For this reason, accessibility to the nuclear-energy generator is limited and many additional, usually expensive, features are required to enable personnel to live and operate in the vicinity—and particularly to perform necessary maintenance operations. The refueling operation itself, when it becomes necessary, can be quite involved. The problem of disposing of the highly radioactive ash from the nuclear furnace is a particularly difficult one. Lastly, the sheer size limitations on nuclear-energy generation seriously limit its applicability to motive power.

To summarize, while nuclear-energy generation has certain attractions, the chief one, and perhaps the only one worthy of serious consideration at this time, is its contribution toward the solution of certain critical problems of fuel logistics. The increased costs and disadvantages of nuclear energy must be justified by its advantages in other areas. The fact is that the application of nuclear power must be subject to, and must survive, rather jaundiced economic scrutiny except, of course, for certain military needs where its peculiar abilities dictate its use without regard to cost—for example, in the submarine. Such military applications may, of course, contribute toward the development of industrial applications.

Mainly, however, it is expected that such military uses will contribute progressive technical knowledge rather than inspire a revolution in the field of industrial power generation.

The Picture in Reverse. Perhaps our perspective on the place for nuclear power can be improved by looking at the picture in reverse. If, for instance, our only source of energy today were nuclear power, we would be searching very hard for alternate sources which would give us greater flexibility in utilization and save capital investment even at the expense of increased fuel costs. Coal would appear to be a godsend as it would permit the construction of cheap and small power plants by comparison with those dictated by the peculiarities of nuclear energy. While railway electrification would be technically practical with nuclear energy as the prime source, we would be facing many needs for rail transport where the high investment costs of electrification could not be afforded. Coal would make possible a peripatetic power plant which would greatly extend the usefulness of our railroads, and the iron horse would appear attractive indeed. Coal would also contribute comfort heat in small packages over areas of diffused population where otherwise such heat would not be available. As a matter of fact, if all of our energy sources were of the large central type, we would find our population jammed into the areas around such heat sources with vast expanses of primitive land between. Therefore, the advent of coal would make possible the population of otherwise unacceptable areas. Coal would also contribute industrial power in small quantities where it might not otherwise have been practical. It would even make possible novel power farming and the old-time steam-traction engine would have a great appeal. In short, the advent of coal to a world subsisting solely on nuclear energy would greatly expand the development of industrial power, heat, power farming, and transportation.

The next step in our backtracking would, of course, lead us to the use of gaseous fuels. Here we would have an extension and amplification of stationary-power generation but practically no contribution to energy generation for motive power. The same considerations, of course, would apply to hydroelectric power.

The Internal-Combustion Engine. Now if, after having worked our way through all of the various sources of stationary energy, someone introduced the liquid-fueled internal-combustion engine (which gaseous and liquid fuels make possible), the revolution in our industrial, civil, and military ways of life would be most spectacular. Here at last we would have a scheme for converting fuel energy into power in any desired quantity—large or small—and unfettered by this to a nonmovable energy source. The essence of the internal-combustion engine is that it converts heat directly into mechanical energy inside the reaction vessel itself. It thereby eliminates the boiler with its accompanying problems of water supply and the complex controls which are dictated by the fact that heat liberation, transfer, and conversion to power are conducted separately, must be individually controlled, and these controls intimately co-ordinated. By the elimination of these intermediate steps, the cost and weight of the power-generating apparatus can be brought down to relatively low levels. As a matter of interest, a modern automobile engine can be purchased ready to run and complete with all necessary accessories for as low as $2.00 per "advertised horsepower." In addition to the low cost and weight made possible by the

internal-combustion engine, its simplicity of operation and its fantastic reliability have contributed immensely to both our civil and military progress (although there are still some few people who do not quite realize this fact of life and who occasionally undertake to resurrect steam for motive-power purposes). In passing, it might be noted that however useful steam power has been and may be (especially when it can be given the necessary skill-operator attention), and how initially cheap it may be in its simple—if inefficient—forms, it cannot match the internal-combustion engine where required sizes are comparatively small and where high mobility is an objective. The simplicity of operation and built-in automaticity of the internal-combustion engine, together with its over-all reliability, bring the automotive vehicle in all of its forms to practical accomplishment. From our imagined starting point of a solely nuclear energy economy we would, therefore, find that not until the advent of liquid fuels would the automobile, the truck, the farm tractor, and the airplane become entirely practicable and acceptable.

WHAT IS THE SCORE?

Since the purpose of this article is to appraise the probable position of nuclear power in the foreseeable future, at this point we should consider the box score. While a great amount of oversimplification must be invoked to cover such an enormous subject in a limited space, it does seem that a reasonable qualitative appraisal of the different energy sources is about as shown in Table I.

Nuclear power is due to develop markedly in the next decade or so. First applications will naturally be made where full advantage can be realized from its unique properties—relative independence from a continuous fuel supply. To this will, in time, be added applications where economics indicate a tolerable disadvantage combined with an attractive opportunity for profitable development. Since power production in the United States seems to double about every 10 years, a place for nuclear power appears logical without too much impact on the further development and installation of conventional power sources. As a wild guess, one might expect nuclear power to assume, over a substantial number of years, a role about on par with hydroelectric power. Where adequate conventional energy sources are available, one should expect development to follow the established pattern. In the motive-power field, particularly, liquid fuels, burned in the gasoline engine, the diesel, and the combustion turbine will continue to carry the lion's share of the load. Nevertheless, it will be interesting to watch the evolution of nuclear power during the coming years as it finds its "place in the sun."

Table I. Qualitative Appraisal of Different Energy Sources

	Economic Potential	Fixed Costs	Fuel Costs	Versatility
Hydroelectric	Small	High	None	Very poor
Coal	Large	High	Medium	Poor
Gas	Large	Moderate	Medium	Fair
Liquid (petroleum)	Large	Least	Moderate	Very good
Nuclear	Large	Very high	High	Limited

REFERENCE

1. Energy in the Future (book), Palmer Cosslett Putnam. D. Van Nostrand Company, Inc., New York, N. Y., 1953.

Units to Supply Power to Uranium Diffusion Plant

Two major electric power plants, which will be the largest ever built by private industry when completed, are now officially in operation. The Ohio Valley Electric Corporation (OVEC) announced that its Clifty Creek plant at Madison, Ind., and Kyger Creek plant at Cheshire, Ohio, (left) are delivering kilowatts to the U. S. Atomic Energy Commission's (AEC) gigantic new uranium diffusion plant near Portsmouth, Ohio.

The first 200,000-kw turbogenerating unit at each of the two plants has been placed in service after several weeks of test, and their power is being delivered to the Portsmouth project via a 330,000-volt transmission system.

Unit 1 at Clifty Creek went into operation approximately on schedule, while unit 1 at Kyger Creek was ahead of schedule by more than a month. These two units will be followed by nine additional and similar machines, bringing the total generating capability to 2.2-million kw when the final units are completed in early 1956.

OVEC was organized October 1, 1952, after the AEC had called upon the private electrical utility industry to provide the tremendous power requirements of the then-projected Portsmouth plant. Fifteen electric companies, all in the Ohio Valley region, teamed to form OVEC.

Engineers and Our National Well Being

DONALD A. QUARLES
FELLOW AIEE

In his address before the First General Assembly of Engineers Joint Council, the author examines our security position as regards "the communist world," including the "technological race," manpower, atomic energy, and nuclear power. A few suggestions are also made concerning a unity organization to represent the engineering profession.

AS AN OFFICER and director of AIEE, I have been interested in Engineers Joint Council (EJC) and the progress of its organizational growth. I have thought and still think that unless or until another unity organization is created, EJC should be the senior policy body representing the engineering profession. I am aware that there are still important segments of the profession not represented on the Council. However, the present membership is so broadly representative of the profession that I believe the Council is entitled to assume—and should assume—the role of spokesman for the U. S. engineering fraternity on professional matters.

A TECHNOLOGICAL RACE

SEVERAL MATTERS stand out in my mind as deserving the thoughtful attention of the profession. I realize these are not new subjects and, in fact, most of them are already receiving the active consideration of those assembled. Since the subjects I will discuss are concerned with our national security policy in one form or another, I think it appropriate to say something about our security position as regards the communist world. This has many facets including mutual security ties with the rest of the free world, economic position, military strength, and the cold war or psychological position. Because this is such a complex question, I am limiting myself to the strictly technical aspect in which engineers would naturally have a primary interest. In this aspect, the cold war is a technological race with the communist world. The question is, "How is our team doing in the race?"

If there is any doubt in anybody's mind that weapon technology is a very important factor in cold-war position, I remind you that even at the present state of development, one airplane in one trip can deliver at great distances a bomb load to destroy one large city. This means that research and development efforts to increase the effectiveness of the payload, to improve the means and reliability of delivering it, and conversely, efforts to defend against it, tend to dominate the national security program.

At the end of World War II, it seemed evident that we had a fairly comfortable technological margin over the communist world. In fact, it is probably not an exaggeration to say that our air-atomic advantage was a principal factor in maintaining a balance of power and, consequently, a semblance of peace. In the decade that has followed, however, the Soviets have made very great strides in improving their technical position. Not only has this been in the atomic field, as evidenced by their atomic test in 1949 and their thermonuclear test in 1953, but also in the fields of aeronautics and electronics—both of which are essential to the effective exploitation of their atomic developments. The quality of the jet fighters they sent into the Korean War and the advanced types of jet bombers in their last May Day air show are adequate evidence in aeronautics.

In electronics, the evidence has been more obscure. Their technical publications have boasted of radio communications and navigational aids. One of these also states that "on bombers airborne radar devices are used as sighting devices for bombing various targets" and shows typical illustrations of airborne-radar planned-position-indicator presentations. The Soviet air defense system is apparently not unlike our own with ground control intercept radars, identify friend-or-foe techniques, spotter networks, and so forth. They have, of course, a very great incentive to build a defense against our atomic retaliatory forces. We got our first concrete evidence of their electronic progress when we saw what a gigantic and sophisticated system they had built up to jam our Voice of America broadcasts.

In the summer of 1953, another significant straw in the wind was seen when the USSR sent the modern cruiser *Sverdlov* to the British coronation ceremonies, bristling not only with guns but with an assortment of search and fire-control radar antennas—very comparable to one of our own cruisers of similar tonnage.

Perhaps the most important thing the Communists have done has been to modernize the educational system and to orient it strongly toward the physical sciences and industrial technology. As a result of comprehensive work along these lines, they have increased scientific and technological potential by an order of magnitude, and, as others have pointed out, they are producing engineers and scientists at more than twice the rate produced in this country. If current trends continue, it will only be a matter of a few years before their scientific and technical manpower exceeds our own.

This is not to imply that even with such numbers they would have a stronger technological base since this depends on many things besides numbers. We would still have the stronger and more virile industrial system, and there is no question in my mind about our ability to stay ahead in this technological race. In the military field, however, it is clear that we are competing with a single-mindedness of purpose

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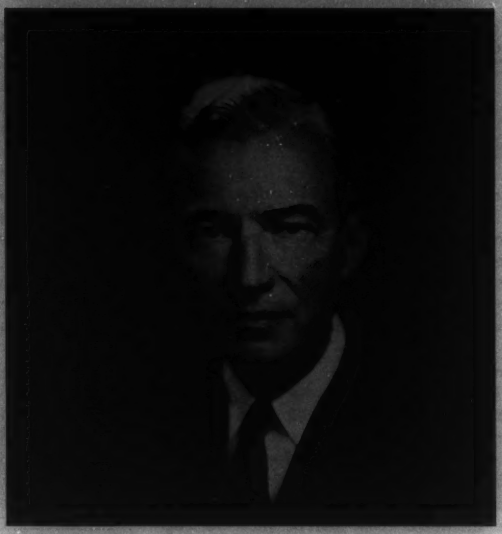
and a ruthless concentration on the aims of militant Communism that constitute a serious challenge to our way of life in the free world.

Fortunately, this situation is clearly recognized by our government, and national policy has been shaped to meet it. President Eisenhower stated this clearly in his recently publicized letter to the Secretary of Defense. The President said, in part, "Due to the destructiveness of modern weapons and the increasing efficiency of long-range bombing aircraft, the United States has reason, for the first time in its history, to be deeply concerned over the serious effects which a sudden attack could conceivably inflict upon our country. . . Because scientific progress exerts a constantly increasing influence upon the character and conduct of war, and because America's most precious possession is the lives of her citizens, we should base our security upon military formations which make the maximum use of science and technology to minimize the numbers of men. . . . Security must be founded on a strong and expanding economy."



Donald A. Quarles

TECHNICAL MANPOWER

This suggests that we should have a careful look at the course we are following in the conservation of scientific and technical manpower. Quite obviously in a long-range sense, our technical position in relation to the communist world will be strongly influenced by the way this manpower problem is handled.

It is thus important for us to work toward national policies that enhance and conserve engineering manpower. The present dilemma about drafting engineers is a case in point. There are good policy reasons for insisting that no young man escape the sacrifice that other young men must make in military service. On the other hand, engineers are scarce and, if we are to sustain a program that will keep us ahead in the technological race, our need for engineers and scientists must be expected to increase rather than decrease.

This is a problem that must be dealt with on a strictly national-interest basis. If we are to win the race, our manpower must be disposed to the greatest national advantage. The military services require some specialists in the performance of their missions. Beyond this, we cannot afford to put engineers and scientists into uniforms.

As you know, we have some important decisions to make along these lines in the months immediately ahead. The Selective Service Act expires on June 30, 1955. Legislation is required to replace it and also to bring our reserve program into line with present-day realities. In this connection, I recently arranged for discussions between members of the Engineering Manpower Commission, the Scientific Manpower Commission, and Mr. Carter L. Burgess, the Assistant Secretary of Defense for Manpower and Personnel. I hope further discussions can be held, not only with responsible officials in the Department of Defense, but also before other government officials and the Congressional Committees that will work on the legislation.

There are also educational aspects of this problem that the Engineering and Scientific Manpower Commissions have addressed themselves to and that deserve the active support of the profession. Best utilization of available engineers requires, too, that industrial and other employers recognize an obligation to develop the full potential of each engineer and to avoid waste of his talents on nontechnical duties.

One aspect of this matter that I should mention briefly is the heavy concentration of technical manpower on defense and defense-related work. In the latter category I include the atomic weapon and military-reactor work of the Atomic Energy Commission, and the research work of the National Advisory Committee for Aeronautics in the aerodynamics and aircraft propulsion fields. It is estimated these defense lines use about one half of the total research and development potential of the country. This is not to say that the results of these programs are useful exclusively for defense. There are, of course, many by-products valuable to the civilian economy. Nor does it imply that the nondefense half of the total national research and development effort is without benefit to defense since, in the long-range sense, defense technology is founded, in large measure, on the fundamental research in the universities and similar insti-

tutions, and on the technology developed in civilian industry.

In my judgment, this great concentration of scientific and technological resources on the problems of defense is not only justified but necessitated by the world situation in which we find ourselves. To do less would jeopardize our position of technological superiority essential to our long-term security. On the other hand, to attempt to use directly on defense projects a bigger proportion of our total potential might be unwise as a long-term program, particularly when one considers the interdependence of the military and civilian fields.

ATOMIC ENERGY AND NUCLEAR POWER

Atomic energy has been a key topic of this assembly. There is no doubt that it deserves this kind of treatment. Some here have been associated with the program from its earliest beginnings. One might say we are just entering the third era. The first was research and crash military development culminating in the Hiroshima and Nagasaki bombs. The second was also dominated by military requirements, culminating in the 1954 thermonuclear experiments, and the third, or power-reactor phase, had its roots in the first two but might be said to have been ushered in by the launching of the *Nautilus* a year ago. Several significant things have happened since. Congress passed the Cole-Hickenlooper Atomic Energy Act last summer which opened the field for private enterprise to develop atomic energy for the greater good and welfare of the country. In line with the President's leadership, Congress also made provision for sharing our very valuable power-reactor know-how, and even moderate amounts of nuclear materials, with other countries. This makes it possible for them to share with us the great benefits of the new technology. On Labor Day, the President, by remote control, broke ground for the first large commercial power plant—first in this country, and so far as is known, first of its size and kind in the world. This, in fact, is just one instance of the many ways in which the Atomic Energy Commission is co-operating with private industry in this field.

Looking to the future, the Commission is spending an estimated $8.5 million a year on general reactor research and development work and is well into a 5-year civilian power-reactor development program, estimated to cost nearly $200 million. The program calls for building five power reactors of as many different types, which were chosen to be the most promising for eventually leading to economic power.

While all of these are experimental, and only one can be called large, they will serve for a period of testing and operation and as the prototypes of large plants where the experimental results are sufficiently promising.

Nuclear power is also of great potential military importance and, in addition to the *Nautilus*, there are half-a-dozen military projects underway, notably to apply nuclear propulsion to aircraft, to large naval vessels as well as submarines, and to an Army project for the development of a semiportable power plant for field use.

There is, of course, a close interplay between this military project and the general reactor development mentioned earlier. Taken as a whole, they constitute a very broad and progressive national program. They will, no doubt, have a very important impact on the development of the industry, both in this country and abroad, in this last half of the twentieth century.

One can hardly deal with the matter of nuclear power without raising a basic question of national policy—the proper place of the government in this field. The question is complicated by the fact that for good and sufficient reasons, the government arrives at the present crossroads with an absolute monopoly in the field, and with national security reasons for perpetuating some aspects of the monopoly. This poses a difficult question. On the one hand, it is apparent that if we really believe in free enterprise and in keeping the government out of all business activities, except those necessary to the public interest and that cannot be properly performed by private enterprise, then the time certainly has come to start getting government out of the atomic power business. On the other hand, there are plausible arguments that the people's money has been spent to develop the art and to produce the fissionable or nuclear fuel materials and the government should, therefore, exploit and operate the power plants "for the people." Of course, the hitch in this argument is the hidden premise that government operation of such power systems would be in the best interest of the people. I, at least, believe that it would not and, therefore, take great satisfaction in the enactment by Congress of the Cole-Hickenlooper Act. This Act, while not proscribing government operation, wisely provided for an orderly transition to private ownership and operation of nuclear-power facilities.

SUGGESTIONS FOR A UNITY ORGANIZATION

In my opening remarks I mentioned an organization of the engineering profession. This subject has been discussed on so many different occasions by so many different groups and with such care and competence that I offer my views with some trepidation. Without further apology, however, I suggest:

1. The guiding principle should be to serve the public welfare, and only to serve the interests of groups of engineers, no matter how large, to the extent that this is incidental to serving the public welfare. I believe this is in the enlightened self-interest of the profession.

2. The unity organization should have professional standards of membership. Membership should be open to all who meet such standards, either directly or through membership in a constituent society. I think that state registration should not be a necessary requirement, at least under present circumstances.

3. The unity organization should be effective in developing the views of the profession, in developing policy for the profession, and in representing the profession in the formulation of national policy. If this kind of effectiveness can only be achieved by individual dues-paying membership, then I am for such membership. But this has never seemed to me to be a paramount consideration. I am sure, however, that the federation concept will only work if there is a sense of urgency in the member bodies to make it work.

Economic Counsel and Modern Management

J. R. HAAS

An essential tool of modern management is economic counsel, although only a minority of companies today seek advice in this field. Present day techniques based on knowledge and experience which are used by competent economists are presented.

As our colleagues who give advice in other fields as law and medicine will tell you, one who advises comes to realize that wise men down through time have labeled it as a business "least likely to succeed." Oscar Wilde remarked, "It is always a silly thing to give advice but to give good advice is absolutely fatal." To expect a fee for it when there's so much of the free variety around is really bucking the tide! Nevertheless, economic counsel is a "growth" industry and a stimulating and rewarding experience for those of us who work at it. Difficult maybe, but never dull. And it's a relatively "new" business too. To be sure, some of the ancient kings had their advisers on the "state of the nation," Adam Smith, Ricardo, and others were largely responsible for the economic legislation in their time. But except for teachers and writers, the profession of economist as discussed today is pretty much a twentieth century creation. Actually, the years during and since World War II mark the biggest jump in the use of professional economists in government, industry, and banking.

But the use of economists outside of teaching and government has not, in my opinion, grown as fast as it should. The fundamental purpose of this article is to demonstrate the place of economic counsel as an essential tool of modern management.

But should such justification be necessary? Aren't we all aware of the way government's increasing role in corporate affairs and other extraneous elements have intruded themselves upon management's direction of private industry? Have not the complexities of these outside factors made self-evident the need for specialized counsel in economics? As George Gobel might put it, "Doesn't everybody know that?" But despite the rapid growth in the use of economic counsel, the fact remains that still only a minority of our corporate and financial organizations seek competent objective advice in this area. Some day it is hoped and expected there will be no need for this topic on your agenda, but your committee is mindful of the realities in having the subject reviewed currently.

MUTUAL UNDERSTANDING NEEDED

Three factors seem to be at fault in retarding acceptance by private industry management of the assistance they can profitably use in the field of economic counsel. First one is the relative "newness" of the business. All new professions require time to "sell" themselves, especially intangible services. Time should cure this. Balance of the blame can be distributed equally between the economists and management.

Let's do a bit of soul-searching among the economists first. Many thoughtful people question whether the world is better, wiser, or richer by reason of the greater quantity of economists and economic data that has evolved in the past 25 to 50 years. Can economics demonstrate to all who need its services that it has become more than "vigorous and ingenious hairsplitting" to use Jewkes' expression? Have some overplayed the role of "court astrologer" to the detriment of their usefulness in areas more within our capabilities and the limitations of the tools at our disposal? We have a real public relations and educational job on our hands in which our limitations should be aired as freely as our apparent capabilities.

Perhaps the "Economist's Ten Commandments" that keep our feet on the ground and our heads from getting too deep in the clouds at my company should get broader dissemination:

1. Do not assume that a Ph.D. in Economics makes you an economist. (Our company wants our economists to have their Ph.D.'s but to keep in mind that the Ph.D. in Economics dates only since the latter part of the last century, which means that Ricardo, for example, didn't have one. And, if again Mr. Gobel can be quoted, "You don't hardly ever see many of them kind no more.")
2. Bear in mind that the record of our profession has not yet demonstrated that the Ph.D.'s have a monopoly on economic knowledge and judgement. (Offhand, five men can be named—three without majors in economics and one without formal university training whose experience and judgment in matters of economics command respect.)
3. Appreciate the distinctions among intelligence, knowledge, wisdom, and judgment.
4. Think of economics as a science but treat it as an art.
5. Seek to know everything about everything—not as a possibility but to goad your thinking and to keep you humble. (The term "economic specialist" is a contradiction. No segment of economics exists in a compartment all its own.)
6. Helping to meet a weekly payroll and earn a return on the investment is the major educational process to which the economist can be exposed.
7. Assume that "people" will act not as they ought but as they usually do. (Do you recall how our post-war "land

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reformers" were going to move vast numbers of people in the Far East from one part of a country to another because it "would be so good for them?" On paper this sounded fine. But one detail was overlooked—the people were happier where they were and didn't want to move.)

8. Do not preoccupy yourself with efforts to sire the next great economic "system" or "theory." Keynes will do until your genius flowers as a result of productive and useful effort. (In the same vein, the late great Nicholas Murray Butler reproved many educators for being more concerned with writing books than they were with developing the minds of their students.)

9. Avoid contamination by the "lunatic fringe" of our profession—the macro-economics of the politician-turned-economist and the self-transplanted mathematician hypnotized by our mountains of statistics.

10. Avoid equivocation as the plague. (One of the finest compliments one can get in our business is, "Well, you fellows certainly stick your chins out." And it is a heart-warming experience to be commended for admitting "I don't know." Naturally those who retain your counsel expect you to be reasonably accurate and informed in your interpretation of the passing economic scene, but I have found that clients are so grateful for your attempts to be definite in what you say, and for a "don't know" response when you don't have a ready answer, that they are pretty charitable on those occasions when you miss the target.)

Now what can management do to improve this faulty liaison between the need for and use of competent economic counsel in private industry, banking, and finance?

Management needs no one to tell it of the mounting intrusion of external factors affecting business plans and profits. No other single group has more to gain from the preservation and propagation of an economic philosophy consistent with the system that has given the United States the highest productive efficiency and standard of living in the world—nor more to lose from a perversion of our economic philosophy. One would assume, then, that management, as a matter of vital self-interest, would long have been in the lead in promoting and evaluating the teaching of economics in our secondary schools and colleges and in utilizing the products of such training.

What are some of the facts that need be considered in improving the situation?

1. Just a few years ago a survey showed that only 10 per cent of economists were connected with private industry, against 20 per cent employed in government, with a steady drift in the latter direction. Good salaries, "security," and "public service prestige" were draining the colleges of instructors and graduates. Washington is still Mecca for many economists. What is likely to be their philosophy with respect to government's position vis-a-vis private industry? To meet this situation, informed management is becoming increasingly aware of the need to advance its economic sophistication and to recruit competent counsel to that end. Education in economics and the profession of economist will benefit too.

2. The Conference Board's *Business Record* for 1950 canvassed 1,000 top companies. Only 1 out of 4 assigned anyone to follow economic developments and in 1 out of 10 cases this was assigned to some executive on a part-time basis. One out of 10 employed a full-time economist. An indeterminate number did retain professional economic counsel, and some relied on their trade associations. Many still felt that reading the papers, talking to customers, etc., were sufficient sources of economic intelligence. If the growth of business at my company is any criterion, this situation is much improved since 1950. And let's keep in mind that these were 1,000 top companies that were surveyed, companies that would logically be the most progressive in their management attitudes. The situation with respect to the thousands of good-sized companies ranking just below this level is in greater need of improvement.

3. It has been said that we distrust what we don't understand. That's true of persons as well as things. Some time ago the American Economics Association had Dun & Bradstreet survey 4,000 top executives on their attitude toward economists. Only 12 per cent were interested enough or felt qualified enough to respond. A few of these disposed of all of us as "crackpots," etc. But that's beside the point—the important thing is management's need to inform itself thoroughly on the nature and direction of a growing body of thought so vital to its own well-being. Government and labor are certainly making ample use of the economists in striving to achieve their objectives.

4. Then many of our management clients tell us they face another problem they are trying to correct—how to improve intracompany dissemination and utilization of economic intelligence. As the president of a large steel company stated it to me, "The younger men coming up to take our jobs will have to know this stuff if they are to deal with government, labor, customers, and competitors." Economics is getting a bigger place in corporation executive training programs.

MISSION OF ECONOMIC COUNSEL

A directory of our corporation clients reads like a list of New York Stock Exchange "blue chips." Forgive me for getting in that "plug" but that's not the point. About the most convincing argument for all management to enlist competent economic guidance is the fact that the managements of so many of America's top companies should deem it necessary or desirable to check their own informed judgment with professional counsel. And some of these companies have their own staff economists too.

But we constitute the "Economic Research Department" for a number of the smaller and medium-sized corporations too. Any management that says, "Retaining economic counsel is all right for those big companies, but we couldn't afford it" has simply been misinformed. It isn't hard to find out.

When people ask you what you do in this business, they're often surprised when you don't mention "forecasts" right off. Comments on this business of forecasting will be given, but first will be summarized, in some priority order, what are considered the responsibilities and duties to the managements that retain us:

1. *Help Management Develop an Economic Philosophy.* You have to take a stand. You have to believe in something.

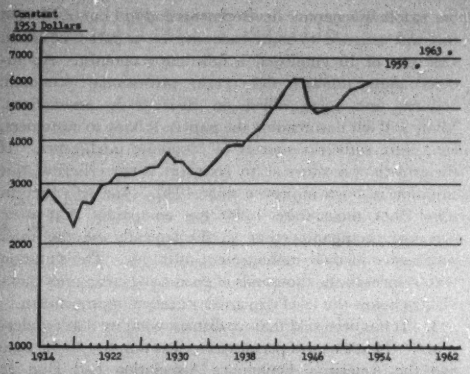

Fig. 1. Gross national product per employed person, 1914 to date, with projections for 1959 and 1963

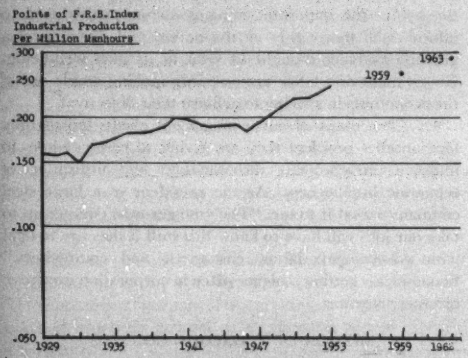

Fig. 2. Industrial output per manhour, 1929 to date, with projections for 1959 and 1963

Remember the "mature economy" boys of the 1930's? Remember how the end of World War II was going to leave us with a vast army of unemployed for "x" years to come? Even as recently as 1953, signs of business "readjustment" were interpreted by many as that long-delayed "big bad post-war depression." So we have tried to make a choice among three basic alternatives for the United States economy: Are we in a long term downtrend in production and values, and standard of living? Are we going nowhere in particular, just sideways? Or, is continued "growth" the right philosophy? Ever since the war the latter has been our position, and still is, and has, in our opinion, been our major contribution to our clients' thinking and planning. You can see why it is rated first—if you're wrong in your basic philosophy, you're pretty likely to be wrong in everything else you tell your clients.

Now, lest you feel that disposing of this major function has been much too casual and unconvincing, a few sample areas are cited of what one might call "concepts and contradictions" in which it is sought to do a useful job of economic orientation:

a. Most were educated in the Wesley Mitchell tradition of "business cycles"—recurrent "booms" and "depressions" that for the most part generated their own corrective forces. But during and since World War II most governments, including our own, have by law assumed responsibility for maintaining "full employment." Most will insist that no one has yet devised a way to eliminate the business cycle from our economy, but is there no obligation to test the reliability of our concept against the implications of this "full employment" philosophy? Or do we retain the mental attitude of the fellow who insists that "the motor car will never replace the horse?"

b. How about the concept of the "capitalistic free enterprise" system spoken of with pride? In theory our productive genius is to produce more and better goods at cheaper and cheaper prices. Frederick Taylor demonstrated that "modern management" could and should engineer increasing output per worker—with equivalent benefits to all: the consumer via lower prices, worker via higher wages, government via larger taxes, and management and investor with commensurate rewards. Instead, the tax collector and labor have tapped the till for the lion's share of the increased product. What statistical "gimmick" in population age shifts since about 1940 has enabled labor to sustain its drive for higher wages? Will its effects be over soon?

c. How does one reconcile the "growth" concept with the stability factor implicit in the search for "security?"

These few samples should invite your reflection as illustrating many areas in which the application of what one thinks he thinks about economics requires re-examination in the light of changing circumstances. Here is where your trained economist can do his most important work for management.

2. *Provide Quantitative Measures of Expected Economic*

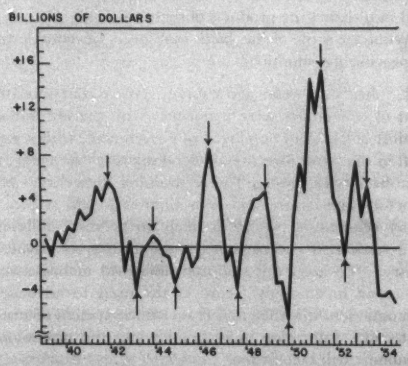

Fig. 3. Quarterly changes in business inventories, seasonally adjusted annual rates

Changes. There is room for vast improvement in the tools and skills needed for this work but we have come a long way since Marshall complained in 1907 about the sluggish growth in the availability of "thorough realistic statistics" needed for the "quantitative determination of the relative strength of different economic forces."

Hence, our clients receive quarterly "economic projections" covering the expected trend by quarters for the ensuing 12 months in such accepted basic economic indicators as the Federal Reserve Board's (FRB) Production Index, Gross National Product, Personal Disposable Income, Consumer Expenditures, Retail Trade, the various price indexes, wages, capital expenditures, and defense spending data. These are designed to suggest the order of change expected in these general economic series as to direction, timing, and amplitude—the three elements of a forecast. Neither we nor our clients expect that we can hit every one of these on the nose every time. However, judgment based on knowledge and experience when applied to a careful analysis of the facts can produce workable quantitative guides with sufficient frequency to justify their use by management.

3. *Application to Major Management Functions.* The conclusions derived from an analysis of near and long-term economic trends pave the way for management decisions in many areas. Long-range outlook will determine distant objectives for sales and production and consequently capital expenditure programs. Answers as to the amount, form, and timing of needed financing for the latter purpose will depend in part on the outlook for interest rates and equity prices. Near term, projected wage trends will affect price policies. Analysis of the inventory cycle will help guide purchasing policy. These are a few samples of the practical uses of economic analysis.

In a business in which one cannot be as specific as one would like, we nevertheless strive to translate our general economic conclusions into terms of the client's particular industry and company. At periodic conferences with top management, attention is directed to four specific areas as a regular order of business, supplemented by such special topics as the client may want added to the meeting agenda:

1. Discussion of general business situation and outlook, and most significant coming developments affecting same, *e.g.*, at the moment, what's ahead in labor and monetary policy? Review of latest revised *Quarterly Economic Projections.*
2. Prospects for client's major "customer industries," *e.g.*, in the case of a steel company client, what's ahead for car/truck output, appliance production, construction, etc.
3. Price/supply outlook for client's major raw materials.
4. Economic analysis of client company's sales. Work in this area has been expanded in the last couple of years. Its purpose is to make more meaningful to corporation clients the practical application of basic economic data and analysis to the demand for their particular products. For

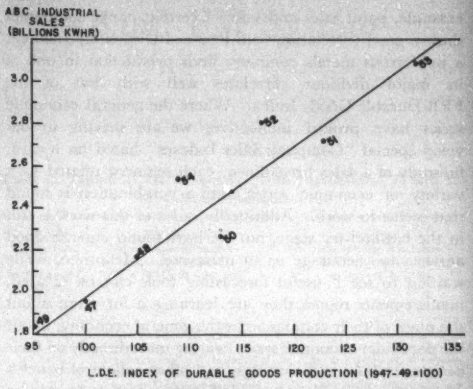

Fig. 5. ABC Light and Power Company's industrial kwhr sales versus Lionel D. Edie "X" area index of durable goods production

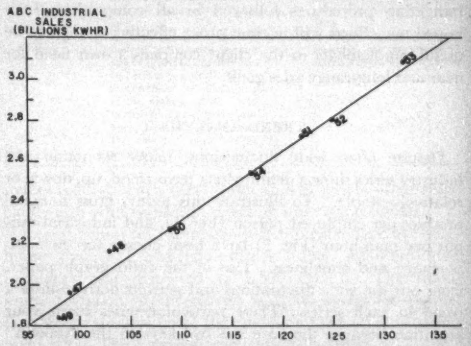

Fig. 6. ABC Light and Power Company's industrial kwhr sales versus adjusted Lionel D. Edie "X" area index of durable goods production

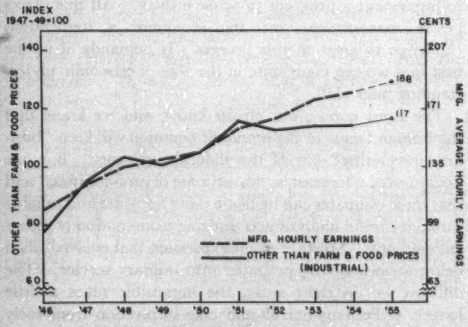

Fig. 4. Manufacturing average hourly earnings versus industrial prices (from the U. S. Department of Labor statistics)

example, paint sales and sales of certain paper companies show a good correlation with Personal Disposable Income; a nonferrous metals company finds production in one of its major divisions correlates well with that of the FRB Durable Goods Index. Where the general economic series have proved ineffective, we are striving to develop special "Company Sales Indexes" based on a careful study of a sales breakdown, each segment related to a variety of economic series until a combination is found that seems to work. Admittedly, a lot of this work is still in the cut-and-try stage, but we have found enough good answers to encourage us to persevere. Meantime, while waiting to see if useful forecasting tools can be created, managements report they are learning a lot more about the place of their companies in the general economy, about the particular economic series bearing most directly on their companies sales and earnings, and other collateral benefits of the work. It might be added that we too are learning a great deal that is not in the economic textbooks.

These "economic sale analysis" efforts of ours are not presumed to be substitutes for the client company's marketing research activities, nor the regular sales planning and budgeting procedures followed in all companies. It is hoped our efforts will in time prove effective enough to be useful supplements to the client company's own need for near and long-range sales goals.

TREND ANALYSIS

Despite often wide fluctuations, many economic and industry series show a definite long term trend, up, down, or relatively stable. To illustrate this today, gross national product per employed person (Fig. 1), and industrial output per man-hour (Fig. 2) have been chosen for their importance and timeliness. Use of the ratio graph paper, irons out the wide fluctuations and permits derivation of a trend in each series. These particular series merit your attention because they are the two keys to the "growth" goals for the United States economy cited in the President's Economic Report to Congress, which incidentally is very much worth your reading.

CYCLE ANALYSIS

Some industry data, such as textile production and consumption, show fairly well established cycles of more or less regular duration. Analysis of inventory swings has always been a major challenge to economists and statisticians. Annual and monthly inventory data have proved ineffective but we have come to regard with some promise the cycle character of these data when plotted on a quarterly basis (Fig. 3). It can be noted that the seasonally adjusted annual rates of inventory change from the preceding quarter with few exceptions tend to show a four-to-five quarters duration from maximum accumulation rate to maximum decumulation rate. This was one of the pieces of evidence that supported our expectation late in 1953 that replenishment of business inventories should be timed for the third or fourth quarter of 1954. The fourth quarter data are not plotted, but reported figures show that the cycle did reverse itself in the fourth quarter, about on schedule.

GAP AND CORRELATION ANALYSIS

When economic series that should move together, based on economic common sense as well as the statistical record, start to diverge, one is alerted to try to explain it and presumably draw some conclusions from such study. There are many examples of these "gaps" especially in the area of prices (Fig. 4). As an example, the "gap" that has opened up since 1951–1952 between Factory Average Hourly Earnings and the so-called Industrial Price Index can be examined. Existence of this "gap" was one of the arguments used over a year ago to combat the prevalent talk of coming widespread price deflation in 1954 and in advising clients to hold the line on prices.

Fig. 4 is also a good sample of "correlation analysis" but Figs. 5 and 6 better illustrate the same thing, as well as some of the complexities that challenge our economic researchers.

A large public utility company client invited our help in selecting some economic index that might correlate with their industrial power sales. Since the company operates in a "heavy industry" area, the FRB Durable Goods Production Index would be the logical selection, after eliminating the aircraft component which is not a big factor in the area served (Fig. 5). But the results for 1954 were not so good. Why? It turned out that while the "Industry X" ranks high in the nation and in the area served, only a small portion of the ABC Company's industrial sales go to "Industry X." Eliminating this "X" component from the FRB Durables Index and replotting, correlation gave the results plotted in Fig. 6—and a tool the company may well find increasingly useful as time goes on.

CONCLUSIONS

There are in the world today tremendous forces for both good and evil. The direction and control of the forces for evil seem to lie in the realm of politics. The direction and control of the forces for good would appear to lie largely in the field of economics. The economic progress recorded in this country continues to confound the pessimists and exceed the fondest dreams of the optimists. The Government itself has set before us impressive economic goals and is trying to implement a program to achieve them. All this places before management and the economist a tremendous challenge to assist in this process. It demands of us the best that we can contribute in the way of economic understanding and skill.

The Lord knows, our clients know, and we know that the human factor in the economic equation will keep "business forecasting" out of the sliderule category. But one definition of a forecast is "an estimate of probabilities," and that these estimates can be made more accurate and reliable through careful analysis and untiring examination of different methods. Most recall the expression that evolved when being thrown poorly prepared into military service, "The difficult we do right away, the impossible takes a little longer." Perhaps one should take inspiration from early readings in philosophy and Jacques Maritain's observation that "It is the error of cowards to mistake a difficulty for an impossibility."

Capture Effect in a Narrow-Band FM System

C. D. HEDGES
ASSOCIATE MEMBER AIEE

THIS investigation was made to study capture effect as it relates to narrow-band FM systems used in the power-line carrier field. Capture effect in FM systems is that phenomenon whereby the stronger of two signals increases its predominance over the weaker signal on the same frequency in a receiver, so that the weaker signal is eliminated from the receiver. The transition in control can be very sharp when one signal becomes even slightly stronger than the other signal. That is, a small differential in r-f input levels of the desired signal to the interfering signal results in a much higher ratio of signal to interference in the audio output. About 10 years ago, FM communication equipment was recommended for power-line carrier use with a major feature being that it possessed capture effect. This phenomenon supposedly would make it possible to work two channels back-to-back at the same station on the same frequency with less isolation between them than would be required for conventional AM channels. From the theoretical study and experimental investigation made by the author, it was concluded that very little if any capture effect was present in narrow-band equipment. This is also the conclusion reached by others in previously published literature.[1,2]

A theoretical investigation of why capture effect is present in FM equipments revealed that the amount of capture effect present is dependent upon the deviation ratio, and thus the total channel bandwidth utilized. An FM broadcast station may employ a maximum deviation of 75 kc and with an audio bandwith of 5 kc, the deviation ratio is 15. The total channel bandwidth utilized is 150 kc. The interference produced by phase modulation in such a system is insignificant when compared to the audio signal developed by a swing of 75,000 cycles. The phase modulation or indirect FM interference signal is caused by mixing of desired and undesired signals. As the deviation ratio is decreased down to 1 as in the case of a power-line carrier FM system, the resulting interference is too high to tolerate for even small FM signals developed indirectly from the interference. It can be shown that a narrow-band FM system is only slightly better than an AM system of the same bandwidth with respect to rejecting interfering signals.

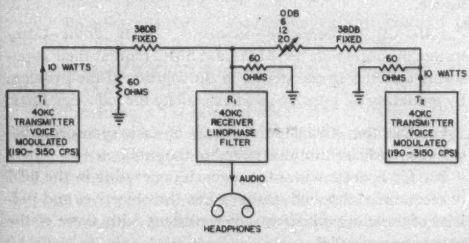

Fig. 1. Block diagram of system for listening test comments

Table I. Listening Test Comments, with Transmitters T_1 and T_2 Modulated Simultaneously

T_1/T_2 R-F carrier level unmodulated (db)	Condition A Unmodulated carriers initially adjusted for a 300-cycle beat note	Condition B Unmodulated carriers initially adjusted for a zero-cycle beat
0	With both signals on, neither is understandable	
6	The desired signal T_1 is understandable but rough and distorted. Undesired signal not understandable but quite loud.	The desired signal over-rides the undesired, and it is readable with practically no difficulty. The undesired signal is quite loud. When the desired signal ceases modulation, the undesired signal is also readable with practically no difficulty.
12	The interference is not tolerable but the desired channel can be understood quite well.	Desired signal is readable with no difficulty, but interference is still too objectionable.
20	With both signals on, the undesired still comes in and can be heard as interference, but it has practically no effect on the understandability of the desired signal. The undesired signal is a nuisance, however, along with the tone and could not be tolerated.	The desired signal is perfectly readable, but the undesired signal is objectionable in the background.

Experimental tests were conducted on standard Westinghouse Type *FD* FM equipments. The maximum AM frequency was restricted to 2,500 cycles. The maximum deviation of the carrier is 2,500 cycles for power-line carrier transmitter so the deviation ratio for this equipment is 1. The listening test comments listed in Table I are significant because the final decision as to whether a system is actually workable is dependent upon favorable listening comments. See Fig. 1.

Thus, there is little if any capture effect present in the narrow-band FM equipment and this is one of the reasons that the equipment is suitable for power-line carrier application. The ability of the narrow-band receiver to receive both the desired signal and noise, neither being favored, allows the signal to be understood in the presence of the noise. However, if a wide-band FM system were applied to a carrier installation and the noise at the receiver input were greater than the desired signal, then the noise would be received and the desired signal eliminated.

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C. D. Hedges is with the Westinghouse Corporation, Baltimore, Md.

High School Teachers of Science

REPORT OF THE EMC-SMC JOINT COMMITTEE ON HIGH SCHOOL TEACHERS OF SCIENCE

The joint committee of the engineering and scientific manpower commissions have studied the urgent problem regarding the inadequate supply of high school science teachers. A proposed plan of action has been formulated as an initial step towards improvement of present conditions.

THE AVAILABILITY of a supply of anything is rarely the result of accident. The word *supply* itself implies planning and production, and as the nation has focused its attention upon its needs in a time of international tension, it has found that judicious planning must be applied to assure an adequate supply of specialized manpower. For the fields of engineering and science it is inevitable that the Engineering Manpower Commission (EMC) and the Scientific Manpower Commission (SMC) play a major role, and that their concern extend to the secondary schools where students commonly choose their careers and where they get the elementary grounding to pursue them.

THE PROBLEM

THE importance of high school science and mathematics teachers in the production of well-qualified engineers and scientists is an accepted fact. The supply of specialized personnel has been inadequate during recent years and various steps have been taken to alleviate the situation. Problems arising at the secondary school level are believed to be of immediate concern. The various aspects of the problem are described in considerable detail in several publications.[1,2,3,4]

These are all excellent publications and point up various problems relating to high school teachers of science and how these affect, either directly or indirectly, the professions involved in the two Commissions. While there are many facets to the broad problem which indeed is highly complicated, it appears that as far as EMC and SMC are concerned, emphasis should be placed on two important questions:

1. What can be done to assist high school teachers of science and mathematics who are already teaching and thus encourage them to continue in such teaching?
2. What can be done to increase the supply of adequately trained high school science and mathematics teachers?

THE ASSIGNMENT

EARLY in 1954 it was felt that matters relating to secondary school science and mathematics teaching should be studied by the Commissions. After official action by both organizations, a Joint Committee on High School Teachers of Science was appointed by the chairmen of the respective Commissions.

The Committee was instructed to study the high school teacher problem and to report on action considered appropriate for the Commissions. It has also considered action for their sponsoring societies, and in turn their local, state, and regional units.

PLAN OF ACTION

Proposed Actions by EMC and SMC. As an initial step toward improving the situation, your Joint Committee proposes that the engineering and scientific manpower commissions take the following actions:

1. Use the *EMC-SMC Newsletter* to publicize matters related to the problem.
2. Co-operate with other agencies operating in the field of secondary school education when the objectives and policies of these organizations are consistent with those of EMC and SMC.
3. Prepare a summary of what various sponsoring societies are doing about this problem and circulate this summary to all sponsoring societies with the hope that each will start new projects and thus increase activity at this level.
4. Prepare a summary of what contributors to EMC and SMC are doing in this field and circulate the report to all contributors with the hope of increasing activity in this group.
5. Co-operate in and encourage sponsorship of projects such as conferences, institutes, symposia, fellowships, etc.
6. Encourage the Advertising Council and other appropriate organizations to stress the high school teacher problem.
7. Co-ordinate in so far as possible the activities of EMC and SMC, its sponsoring societies, and its contributors.

Many of the proposed actions outlined above are now being accomplished. They have been included as a matter of record, and to indicate the need for more emphasis in the future.

EMC-SMC Sponsoring Societies. Your Joint Committee proposes that the EMC and SMC request their sponsoring societies to co-operate in the solution of the problem by rendering all possible assistance along the following lines:

1. Use the official publications of each sponsoring society to publicize matters related to the problem.
2. Co-operate with other agencies operating in the field of secondary school education when the objectives and policies of these organizations are consistent with those of the sponsoring societies.
3. Co-operate in and encourage sponsorship of projects

Personnel of the EMC-SMC Joint Committee on High School Teachers of Science: G. A. Hathaway, *Co-Chairman*, EMC; B. R. Stanerson, *Co-Chairman*, SMC; Henry Armsby, H. G. Dixon, M. D. Hooven, Milton Lee, and Dael Wolfle.

for high school science and mathematics teachers such as conferences, institutes, symposia, fellowships, etc.

4. Assist in obtaining science-related summer employment for high school teachers.

5. Arrange programs of interest to high school teachers.

6. Encourage local, state, and regional units to develop programs dealing with the secondary school science teacher problem.

Local, State, and Regional Units. Since changes in and assistance to secondary school education must be brought about largely at the local level, the importance of a well-planned grass roots program through the units of the several sponsoring societies of EMC and SMC must not be underestimated. Members of one or more of the societies can be found in most school districts of the nation where they can work and become closely acquainted with their professional colleagues, the high school teachers. Among the 400,000 members of the constituent societies are many influential citizens in a position to render valuable assistance.

Because of the large number of local, state, and regional units involved, some co-ordination of activities is necessary to prevent duplication of effort and inefficiency of operation. In many cases, local engineering and scientific councils will provide a convenient means of co-ordination. In every case, sponsoring societies should call attention to various organizations that may be engaged in similar activities.

It would be difficult if not impossible to list all activities suitable for local, state, and regional units. Local conditions will determine which are feasible and most effective.

Your Joint Committee proposes that the EMC-SMC sponsoring societies request their local, state, and regional units to assist by:

1. Promoting the organization of activities helpful to high school science teachers through state academies of science; junior academies of science; engineering, scientific, and industry councils; service clubs; school organizations; and similar groups.

2. Assisting high school teachers in obtaining science-related summer employment.

3. Promoting, sponsoring, and financing the attendance of high school teachers at conferences, institutes, symposia, and such other activities as may improve their teaching ability.

4. Arranging programs of interest to high school teachers.

5. Assisting in arranging plant and laboratory trips for high school teachers and their students.

6. Co-operating in or sponsoring various contests of interest to high school teachers and their students.

7. Assisting teachers in planning and obtaining adequate libraries and laboratory facilities.

8. Providing a list of local specialists in various fields to whom teachers can turn for advice and assistance, especially with respect to projects carried out by their students.

9. Providing a list of available speakers on topics of interest to high school teachers and their students.

10. Sponsoring radio and television programs to publicize the importance of good teaching of science and mathematics in high school.

11. Encouraging member participation in various activities at the high school level.

12. Promoting, encouraging, and participating in guidance services for high school students, in which the requisite qualifications and opportunities for, and the advantages and disadvantages of, careers in engineering, science, and science teaching are honestly and realistically presented.

13. Reporting on the effectiveness of projects to the parent society, EMC, and SMC so that information can be disseminated and thus shared by other organizations.

Recommendations. Therefore, the EMC-SMC Joint Committee on High School Teachers of Science submits the following recommendations for consideration:

1. That copies of this report be distributed to members of EMC and SMC and that discussion of the report be included as an item on the agenda for the next meeting with a view to approval and implementation of actions proposed under Section *A*.

2. That EMC refer the approved report to Engineers Joint Council for appropriate action by each of its constituent societies as proposed under Section *B* and, further, that the constituent societies request their local, state, and regional units to assist by implementation of the proposed actions outlined under Section *C* of this report.

3. That the SMC refer the approved report to their constituent societies as proposed under Section *A* and, further, that the constituent societies request their local, state, and regional units to assist by implementation of the proposed actions outlined under Section *C* of this report.

4. That the EMC and the SMC continue their interest and activity in the field with particular emphasis toward co-ordinating the work of the numerous local, state, and regional organizations interested in the high school science teacher problem.

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Instant Computation of Power Losses

A new analogue computer is facilitating calculations of the most economical means of generating and transmitting electric power through nearly 8,400 miles of high-voltage transmission lines. General Electric's general engineering laboratory recently announced that the computer is now in service at the "nerve center" of the American Gas and Electric System in Columbus, Ohio.

Its 1,290 dials can be set for the system's major load centers, interconnections with other systems, the amount of electricity being generated at different plants, and the distribution of users in the 46,000-square-mile service area.

Safety Aspects of Nuclear Reactor Control

J. I. OWENS
ASSOCIATE MEMBER AIEE

J. H. PIGOTT

Reactor power plants can now be designed and operated so they present no greater danger to operating personnel than conventional power plants. They can also be shown to offer negligible danger to the surrounding geographical area. At present, the extremely conservative assumptions concerning the safety system necessitate a very complex design. As operating experience accumulates, it should be possible to simplify the design.

THE future of atomic power depends upon the ability to operate atomic reactors safely in or near large population centers. There are two major phases necessary before this can occur. The first phase involves the technological advances necessary to assure that the probability of any damaging accident to the plant is negligibly small and insuring that in the very remote occurrence of any such accident the people in the surrounding areas will be unhurt. This phase has received much attention in the last 10 years and is capable of achievement.

The second phase involves public acceptance of atomic reactors and their safety. Since much of the initial publicity concerning the atom has involved its destructive power when properly utilized in a bomb, most public thinking has followed this channel. It will be necessary to demonstrate that a reactor constructed for power purposes is physically incapable of a violent explosion and to demonstrate that while there is potential danger it can be controlled by proper design.

Government surveillance of problems involving public safety is, and will continue to be, necessary. In the atomic power field these problems are handled by the "Atomic Energy Commission Advisory Committee on Reactor Safeguards." This committee carefully reviews the design of all the reactors that are constructed in the United States for the purpose of insuring that adequate safety features have been built into the plant. The design approach to date has been a very conservative one in which safety factor has been piled on top of safety factor. But this is as it should and must be since there is still much that is to be discovered in this new and promising field. As in all developments, only experience will permit optimum design to reduce complexity and will allow more realistic hazard evaluation. That the problems are not insurmountable is demonstrated by the fact that at this moment there is under construction, less than 20 miles from Schenectady, N. Y., a naval reactor power plant. This plant is the first of substantial rating to be built near a large population center and is a demonstration of confidence that such plants can be safely constructed.

Safeguard aspects of power reactors may be divided into two categories: aspects which involve accidents which will damage the power plant, itself, without doing appreciable damage to the surrounding countryside; and aspects involving accidents which could conceivably do damage to the surrounding countryside. Because of the careful control of safety, hazards to the operating personnel of an atomic power plant are probably less than those in conventional power or chemical plants. As a matter of fact, safety records in AEC installations speak eloquently of the ability to control these hazards. It is not the purpose of this article to describe accidents of this nature.

Reactor designers must assure that accidents falling in the second category cannot exist. This can be done by examining the mechanism of such an accident and providing means of preventing the accident. First it can be shown that a reactor which is constructed for power purposes is physically incapable of a violent explosion. The danger lies in the possible disintegration of the reactor core and the dispersal of the highly radioactive fission fragments over the surrounding countryside. This could conceivably be more severe than in the case of an atomic bomb since the bomb generates a surprisingly effective thermal column which transports the majority of its fission fragments to the upper reaches of the atmosphere where they are quite finely dispersed. The core disintegration and subsequent dispersal could be triggered by achieving a very high reactor power resulting in coolant boiling and fuel-element disintegration, or by a violent chemical reaction resulting in extreme system pressures. The former could be accompanied by temperatures and pressures high enough to rupture any containing vessel. With the latter, rupture of the containing vessel and subsequent loss of coolant would again cause disintegration of the fuel elements.

In a sodium-cooled plant, the chemical reaction described above might result by a major failure allowing intimate contact between large volumes of water and sodium. This can be prevented by careful design to minimize and localize areas of possible contact.

The nuclear incident described is more unique and will be discussed in greater detail.

REACTOR KINETICS

THE heat produced in a reactor results from the kinetic energy of the nuclear fragments formed in fission; thus the rate at which fissions are occurring provides a measure of the rate of heat generation. When fissions are occurring at a constant rate, the power will be constant. This state is

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referred to as the reactor being at critical. From each fission which is initiated by a neutron on the average of J neutrons are given off in addition to the heavier nuclear fragments. A number of things may happen to these neutrons. They may be captured by some nonfissionable material in the reactor, called a poison, or they may escape from the reactor, or they may be captured by a fissionable nucleus and thus produce another fission. It is apparent that for a constant power level just one of the J neutrons, on the average, must go into producing another fission. How many do go into this process depends on the competition between various processes. The number which produces fission may be increased by increasing the amount of fissionable material in the reactor while keeping the other constituents the same. The number may be decreased by increasing the amount of poison material, thus leading to a greater share of nonfission capture, or the number that escape may be increased by decreasing the size of the reactor or by increasing the transparency of the reactor. The transparency of the reactor is dependent on the amount of substances whose nuclei the neutrons may collide with and rebound. This material is called the moderator.

The state of the reactor may be described by a quantity called effective K, defined as the number of neutrons produced per neutron lost to all processes. At critical, K is exactly 1. A time l which is the mean lifetime of a neutron may also be defined. Now if all neutrons were produced immediately, which they are not, and if at time t the power level were P, then at time t plus l the power would be KP, and in general there would be for the rate of change of power

$$l(dP)/(dt) = (K-1)P$$

with the solution

$$P = P_o e^{\left(\frac{k-1}{l}\right)t}$$

where P_o is the power level at time zero. For most reactors the quantity l varies from 10^{-3} to 10^{-5} second. Thus it may be seen that in order for the reaction not to run away very rapidly K must be very close to 1. Among other things, this means that a reactor must be loaded very carefully and that its controls must not effect sudden major changes in its structure or composition.

Fortunately the previous equation is an over-simplification. Not all neutrons produced by fission are available immediately. Somewhat less than 1 per cent are given off, after some delay, by the fission fragments and are called delayed neutrons. The half lives of these vary from 0.05 to 55 seconds. Their effect is to reduce considerably the rates of change of power for reactivities which are less than the delayed neutron fraction. The excess reactivity $(K-1)$ in dollars is defined as the ratio of excess reactivity to the delayed neutron fraction. Note that if the excess reactivity exceeds \$1, i.e., $K-1$ is greater than the delayed neutron fraction, the reactor rate of power increase is no longer inhibited by the delayed neutrons. For a constant positive excess reactivity, the reactor power will increase asymptotically according to the relation

$$P = ke^{t/tp}$$

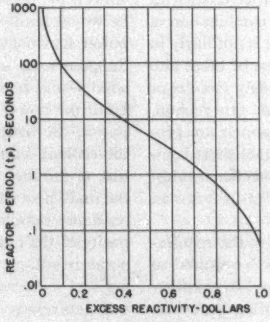
where k is somewhat larger than the initial power level, and tp is the time required for the power to increase by a factor of $e = 2.71828$ and is called the period of the reactor. Fig. 1 shows the period as a function of excess reactivity in dollars.

Note that for excess reactivities below 0.40, the periods are moderate (greater than 10 seconds); but for excess reactivities above 0.75 and approaching 1 they become quite short, less than 1 second to 0.06 second at \$1. Thus one of the cardinal rules in avoiding nuclear accidents is to prevent the reactivity being suddenly increased to above \$1.

MEANS OF CONTROL OF REACTORS

As described previously, the reactivity K of the reactor may be varied by changing the amount of nonfissionable capturing material—poison—in the reactor, or changing the amount of fissionable material, or by changing the escape of neutrons from the reactor. Of these three, the first and third methods have thus far seemed most practical for high power producing reactors.

Poisoning of the reactor may be accomplished by a number of rods containing a poisonous material, such as boron, which may be inserted in the core of the reactor. Control of escape may be accomplished by varying the composition of the reflector. The reflector is a blanket of moderating or scattering material surrounding the core of the reactor used to reduce leakage of neutrons from the reactor. The core contains the fissionable material. Control by the second means may be accomplished by fuel rods which may be withdrawn from the reactor.



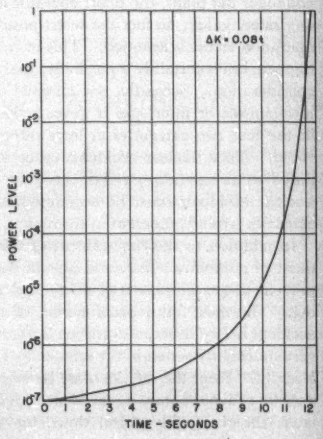


Fig. 1(above). Reactor period versus reactivity. Fig. 2 (right). Power versus time with linearly increasing reactivity

AMOUNT OF EXCESS REACTIVITY REQUIRED

As just discussed, the amount of reactivity needed to effect changes in power of the reactor is small and certainly for any conceivable power application less than $1. However, just as there are several means of control of reactivity, there are many causes of variation of reactivity of the reactor during its lifetime, which must be compensated for by the controls. These are summarized as follows:

Cause of Change	Direction of Change
Burn-up of fuel	Negative
Accumulation of fission products	Negative
Accumulation of short lifetime poisons resulting from fission	Negative
Increase of operating temperature	Negative or positive(small)

From this table it may be seen that the reactor will be more reactive when it is first operated than it will be after it has been operated a considerable time. The reactivity variation may be many dollars which must be compensated for by controls. A primary requirement on the controls must be that these compensating reactivity changes must be made in a manner that is safe.

TYPES OF CONTROL

The various functions of reactor control will need to be referred to separately, although they may all be accomplished by the same mechanism. The control member that is used to provide regulation of power output is called the fine control or regulating rod. The member or members used to compensate for relatively slowly varying reactivity changes are called the shims. The members used to decrease reactivity rapidly in case of an impending accident are called the safeties.

PREVENTION OF NUCLEAR INCIDENTS

Before discussing in detail reactor safety systems, it is well to review the design philosophy of these systems. In general, in considering nuclear incidents which might endanger the plant, the plant operator is not credited with any safety value; in fact the worst possible combination of operation errors is assumed. This of course is not likely to happen, but is certainly a possibility that must be taken into consideration. Secondly, one channel of safety circuits or mechanisms or interlocks is never relied on. In general, in the first two categories at least three channels are provided. Since nuclear accidents occur in times short compared to an operator's reflex time, the protection against nuclear accidents must be automatic and, to as large an extent as possible, inherent in the design.

In addition to the requirement of safety, is the requirement of reliability. Extreme care in design is required to prevent the requirements of safety and reliability conflicting. The most failureproof system of stopping a nuclear accident before it becomes serious is to reduce the reactivity very quickly by action of the safeties. This action is called a scram. Since the safeties must be reset very slowly after a scram to avoid a start-up accident which will be explained later, the plant will be shut down for some time. Now for every circuit which is provided to initiate such an action, there is introduced the possibility of a scram due to a false signal from the circuit itself. Thus the designer must avoid adding safety circuits which will scram the reactor for causes which represent no danger, though they may involve improper operation.

One of the primary causes of a nuclear incident is a sudden increase of reactivity near to or beyond $1. This means that the reactor must be designed to be mechanically rigid so that there can be no sudden changes in structure. If the draining of coolant causes an increase in reactivity, which is not generally the case, great precautions must be taken so that the coolant cannot be lost. This is of course important for safety reasons other than the nuclear incident. Finally, any rapidly moving control rods which can move in either increasing or decreasing reactivity directions must be limited in total reactivity to well below $1. The only one of the control members that may be required to move rapidly in either direction is the fine control and in that case the amount of reactivity must be limited to less than $1. The safeties need act rapidly only in the decreasing reactivity direction.

The shims must be capable of varying the reactivity, in general, in either direction by amounts well in excess of $1. During operation at power they are required to move only very slowly and can thus not increase the reactivity far above critical before the power level gets so high that safety action is initiated. The only time they represent a possible danger is during start-up of the reactor when it is being brought from extremely low power level, and far below critical, to critical at power. At start-up the reactor may be at a power level of from 10^{-6} to 10^{-10} of full power and several dollars below critical. Also if the reactor has been shut down for some time the exact position of the control elements which will attain criticality will not be known. Fig. 2* shows the power variation that would occur if shims were used to increase reactivity at a constant rate starting at 10^{-7} below full power. It may be seen that for a rate of $0.08 per second, the power increases from 1-per-cent power to 100-per-cent power in less than 0.2 second. Thus if the operator had only a linear power output meter he would hardly notice anything had happened before the power had begun to increase at an extremely rapid rate. Suppose such an accident were permitted, and consider what would happen if no corrective action were initiated. Until the power level has reached about 1 per cent of full power, the temperature of the fuel will be approximately the coolant temperature. Beyond this value the temperature of the fuel will begin to rise quite rapidly because of the small heat capacity of the fuel. Because of the thermal resistance between fuel and coolant and the large heat capacity of the coolant relative to the fuel, the coolant temperature will not increase nearly so rapidly. After a limiting fuel temperature is reached, the fuel will disintegrate and thus release its stored energy to the coolant. Some or all of the coolant may vaporize leading to a considerable increase in system pressure. The combined effects of coolant vaporization, at least locally, and the entering coolant

* This curve was calculated under the direction of J. E. Barnes of the Knolls Atomic Power Laboratory.

will sweep the fuel out of the reactor and eventually stop the reaction. It may be seen from these qualitative considerations that this type of nuclear accident is not likely to create an extremely large explosion but the energy release may be sufficient to rupture the reactor container and thus release fission products to the outside. In order to limit the size of the possible start-up accident, the rate of increase of reactivity with the shims is severely limited and provides means of preventing such accidents.

To guard against nuclear accidents, various safety circuits are included in the reactor control design. The most important of these is the excess power or flux scram circuit. This consists of a number of ion chambers which monitor the neutron power and, when this exceeds a prescribed level, release the safeties so that they are driven to decrease reactivity very rapidly. A second circuit for protection largely in start-up is the period scram. By means of ion chambers and special circuits this measures the reactor period and, when the period is smaller than a prescribed amount, releases the safeties. When operative, this circuit will detect an incipient start-up accident before operating power is reached. However in line with the philosophy enumerated earlier, this circuit is not relied on exclusively and the rate of motion of the shims is limited to a value which will allow the power level scram circuit to control the start-up incident without disrupting the fuel elements.

OTHER THAN NUCLEAR ACCIDENTS

OTHER ACCIDENTS that may endanger the reactor plant and occupants of the plant building are failure of coolant flow, loss of system pressure in a water plant, and leakage of system coolant.

The first of these may be quite serious because of the very small heat capacity of the reactor core. If the reactor is not shut down immediately following a loss of coolant flow, the temperature of the coolant will rise very rapidly. This may lead to boiling of the coolant with severe damage to the plant. For this reason the pumps and their power feeds must be made very reliable and the plant must be shut down to a very low power level by the safeties immediately after loss of flow. Use of multiple cooling loops or multiple pumps reduces this problem and an emergency cooling system, usually of natural connection type, is often provided to remove the residual heat.

Loss of system pressure in a water plant will also lead to boiling with damage to the reactor. Fortunately in both this case and the case of loss of coolant flow, boiling of the coolant will generally reduce reactivity and the action is to some extent self controlling.

The leakage of coolant, unless it is very severe, largely represents a radiological, fire, or scalding hazard to the occupants of the plant building.

BASIC ELEMENTS OF REACTOR SAFETY SYSTEM DESIGN

A SOMEWHAT OVERSIMPLIFIED block diagram is given in Fig. 3, showing some basic elements of a reactor safety system. Multiple safety members are shown on the diagram and in general the design of the safety system will be such that only a fraction of these are required to cope with the worst possible nuclear accident. Energy accumulators are provided in the form of springs or flywheels so that activation of the safeties is independent of externally supplied energy. The release device may be a magnet or latch which holds the safety in position as long as a holding signal is present. Scram will be initiated by the disappearance of the holding signal. Ion chambers are used to monitor the neutron flux and furnish currents to the power level and period trip circuits.

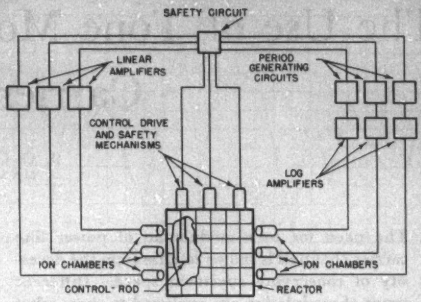


Fig. 3. Flux monitoring portion of a typical reactor safety system

The time required from the beginning of a scram action to the initiation of safety action and the time for complete stroke of the safeties must be made small and must be demonstrated to be adequate to protect against any accident.

CONCLUSION

REACTOR POWER PLANTS can be designed and operated so that they present no more danger to operating personnel than conventional power plants. They can be demonstrated to offer negligible danger to the surrounding countryside. At the present stage of knowledge, the design of the safety system is based on extremely pessimistic assumptions leading to a complex design. Increased knowledge gained by operating experience should allow relaxation of the assumptions and simplification of the design.

"Night Viewer" Aids in Security Work

A portable viewer that permits vision in complete darkness for distances up to 12,000 feet was introduced recently by the Curtiss-Wright Corporation, Wood-Ridge, N. J., as one in a series of new Curtiss-Wright products in the fields of ultrasonics, electronics, and plastics.

Normal applications for the "Night Viewer" are in security work on the part of police and customs guards and in industry where processes cannot be conducted in normal light. It consists of an infrared radiator which projects a beam invisible to the human eye upon a selected object or location, and a receiver that converts the reflected infrared image to rays visible in the viewer. These two units are synchronized for simultaneous focusing upon an object.

The Use of Tone Modulation Over Complex Carrier Channels

J. C. G. CARTER
MEMBER AIEE

The need for tone modulation of power line carrier channels is shown to arise from the necessity of conserving spectrum space. Different types of modulation are analyzed to show what frequencies actually are transmitted. The characteristics of carrier channels are discussed and the results of uneven attenuation and phase displacement over the transmission bandwidth are pointed out. Methods of improving carrier channel characteristics are included, as well as recommendations for selection of tone equipment to avoid the adverse effects of channel distortion.

FREQUENCY crowding in the power line carrier spectrum is one of the most pressing problems confronting the industry at present. It necessitates having as many channels as possible in the narrowest possible band. Telegraphic functions, such as telemetering and supervisory control, do not in themselves take up much bandwidth. There are two methods of transmission used at present to take advantage of this fact: closely spaced narrow-band carrier channels, keyed frequency shift or on-off; and modulation of the main carrier by a group of subcarriers or audio tones.

Various factors will dictate the choice between the two methods—the cost of the r-f equipment, the cost of the tone equipment, the number of channels involved and whether they are all going between the same points, and the relative reliability of the two forms of transmission. This article presents a study of the tone-modulation method with a view to determining its reliability, when transmitted over a complex carrier channel.

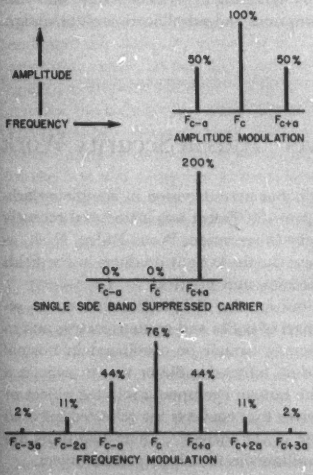


Fig. 1. Side frequency distribution for different types of modulation of carrier wave by a single audio tone

TYPES OF MODULATION

THERE are three methods of modulation of a carrier by a tone in use today: double side-band AM, FM, and single side band with the carrier wholly or partly suppressed, this being a derivative of AM.

A brief analysis of the three types is necessary to show how each is affected by the transmission medium. A more detailed discussion can be found in previously published literature.[1]

When a carrier wave is amplitude modulated by a single audio frequency, in addition to the carrier, two side frequencies are produced, above and below the carrier frequency by an interval equal to the audio frequency. The amplitude of the side frequencies is equal, and directly proportional to the amplitude of the modulating voltage.

It is possible to suppress one of the side frequencies, say the lower, and the carrier itself, and transmit only the upper side frequency. The carrier is reintroduced in the receiving equipment, and by a demodulation process the original modulating audio is reproduced. This is single side-band transmission. The side-frequency amplitude is directly proportional to the modulating voltage. Sometimes a small constant amount of the carrier frequency is transmitted, for synchronizing the reintroduced carrier or for automatic-volume-control (a-v-c) purposes.

In frequency modulation, a number of side frequencies are produced for each modulating frequency. They are spaced in multiples of the modulating frequency above and below the carrier frequency and are theoretically infinite in number. Their relative amplitude and that of the carrier depends on the deviation ratio, which is the maximum swing of the carrier above and below the center frequency due to modulation, divided by the modulating frequency.

Fig. 1 shows a chart of the side-frequency distribution for the three types of modulation. Only the three lowest-order side frequencies are shown for FM, the higher order ones being too small to be significant. The relative ampli-

Full text of paper 54-321, "A Study of the Use of Tone Modulation Over Complex Carrier Channels," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Published in AIEE *Transactions*, vol. 73, pt. III, 1954, pp. 1453-9.

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tudes are those for 100-percent modulation or equivalent, and a deviation ratio of 1 for the FM.

CHANNEL CHARACTERISTICS

When modulated r-f signals are transmitted through space, they usually arrive at the receiver in the same form as they are originally radiated. The over-all amplitude is considerably reduced, but the relative amplitudes and phase relations of the various components of the wave are unchanged. When the medium is a power line, this is seldom the case.

Effect of Tuning Equipment. The resonant type of coupling equipment presents a true resistive path only at the resonant frequency. On either side of resonance there is a phase displacement, and some degree of attenuation. The amount of these variations depends on the Q of the circuit, which is determined by the line impedance and the reactance of the coupling capacitor at the transmitted frequency. The effect is worse when the line impedance is low, the line voltage high giving small coupling capacitance, and the frequency low giving high capacitive reactance. If the carrier channel has a number of by-passes, in addition to the terminal coupling equipment, the effect is multiplied considerably.

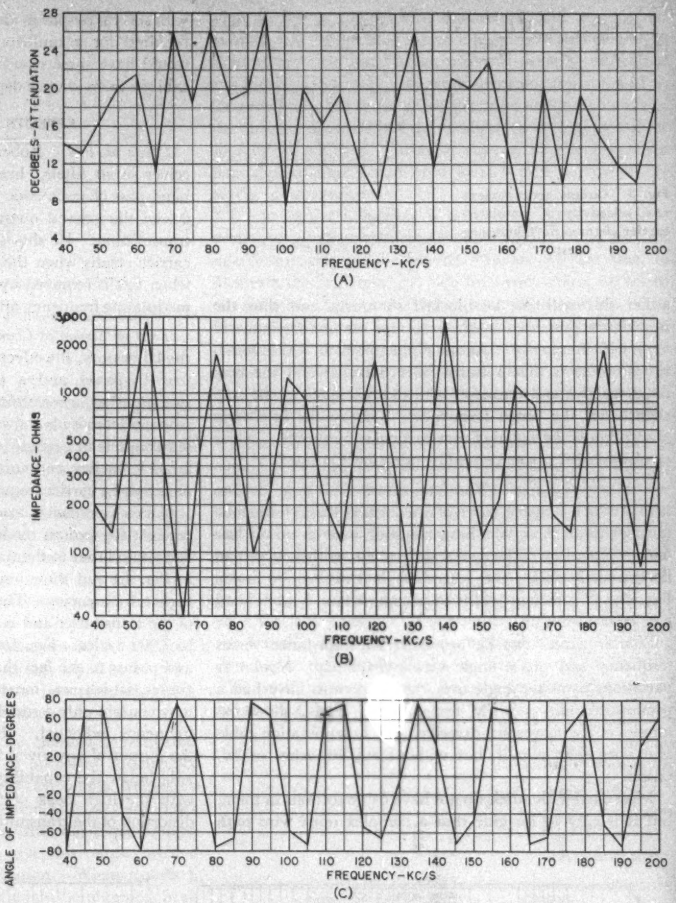


Fig. 2. Frequency characteristics of a power line carrier channel:

A—Attenuation; B—Impedance; C—Phase angle

With the nonresonant type of coupler, the attenuation variation over the bandwidth of the transmission is less, but this kind of coupler can only be adjusted for a resistive path at one frequency, and it is shown[2] that at all other frequencies there is a phase displacement and some relative attenuation.

Effect of Mismatches. Mismatches occur at a number of places. The receiver input impedance is usually high compared to the characteristic impedance of the coaxial cable feeding it, so the cable is not properly terminated. If there is a low impedance bus at the receiving location, this will effectively terminate the line in a mismatch. If the signal divides at any point, there is a mismatch due to one line terminating in two lines in parallel.

At each of these mismatch points there is a reflection of the signal causing standing waves. The result is that at the transmitting point the impedance may be quite different from the characteristic line impedance, and may be reactive. Moreover the phase angle and magnitude will change with frequency.

A transition from open wire to power cable or vice versa creates a serious mismatch for a carrier signal, since the impedance of open wire is around 400 ohms, and that of cable about 25 ohms. A short stub line, if terminated in an open breaker, can present a short circuit to the main carrier channel at an electrical length of an odd quarter wave, and thus provides an extreme case of mismatch at the junction point.

Effect of Traps. A sharp tuned trap will block the resonant frequency from a given path, but frequencies on

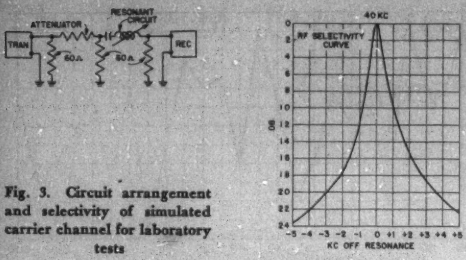


Fig. 3. Circuit arrangement and selectivity of simulated carrier channel for laboratory tests

either side will not be blocked so much, and thus the impedance presented by the trap and the line beyond will vary with frequency. Another phenomenon which sometimes occurs is that a transformer bank beyond the trap looks reactive and resonates with the reactance or the trap slightly off the tuned frequency. This results in a high absorption of the signal of that particular frequency. This can be avoided to some extent by using low Q traps.[3]

Characteristic Curves. The total effect of all these devices is to produce a jagged curve of attenuation versus frequency familiar to all those who have run such tests on power line carrier channels. The peaks and valleys in this curve can be extremely sharp, and sometimes it is difficult to find a flat spot of sufficient width to accommodate a modulated carrier transmission.

Similar curves can be produced for impedance versus frequency and phase angle versus frequency. Nonlinear variations in phase angle over the bandwidth have had a pronounced effect on FM transmission. Fig. 2 shows examples of the curves just described, for a combination cable and open wire circuit, but without any branches or bypasses.

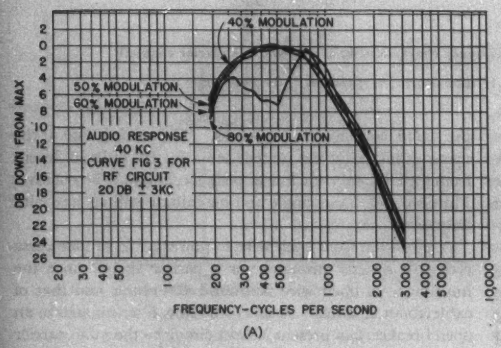
Most carrier channels do not have cable sections in them, but it is easy to imagine that a complex open wire path with several by-passes and branch circuits, such as might be required for a multistation supervisory control network, would have these characteristics. Actually every channel exhibits them to some degree.

EFFECTS ON MODULATION

Effects on FM. Robert L. Fillmore, in a paper on receiver input filters,[4] has analyzed the effect of a narrow band-pass characteristic on FM transmission, and also discussed the general question of distortion due to nonlinear transmission. He shows that amplitude modulation of the carrier results when the bandwidth is restricted, and even when this is removed by the limiter, odd harmonics of the modulating frequency are produced.

Tests on Simulated Channel. On a recent investigation in the laboratory, the effect of a channel on a 115-kv line with four by-passes and a pair of terminal equipments was simulated by transmitting through a sharp tuned circuit, whose selectivity is shown in Fig. 3. This is equivalent to ten couplers in cascade, each consisting of a 0.00187 microfarad capacitor and tuner, with a line impedance of 400 ohms, and a carrier frequency of 40 kc.

Curves were run of amplitude versus frequency out of the receiver for various modulation indices for a constant voltage audio input to the transmitter. These curves are given in Fig. 4*A* and show how the amplitude is reduced at the higher frequencies. The normal band-pass characteristic of the transmitter and receiver is flat within 5 db from 250 to 2,900 cycles. Fig. 4*B* shows distortion versus frequency and points to the fact that the amplitude in the first set of curves, which was measured with an untuned voltmeter, may contain only a small proportion of fundamental at the frequency indicated. From this it may be deduced that the output of any given frequency in the band is considerably below the capability of the receiver. By comparison with the high peak of this distortion curve, the over-all distortion of the transmitter and receiver over a flat channel



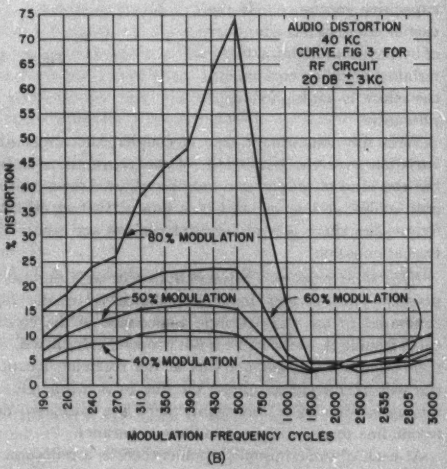


Fig. 4. Audio output characteristics from selective carrier channel:

A—Amplitude versus frequency; B—Per-cent distortion versus frequency

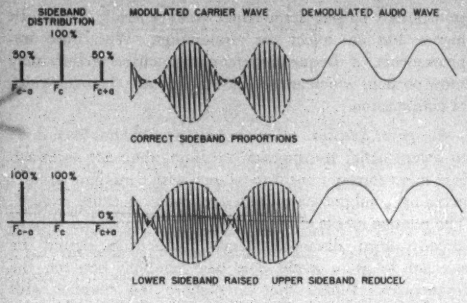


Fig. 5. Effect on demodulated wave of unequal transmission of side frequencies

at 500 cycles audio-frequency and 40 kc radio-frequency, even when 100-per-cent modulated, is only 6 per cent.

Tests made at higher carrier frequencies showed less distortion. Also lower distortion was obtained with a higher value of coupling capacitance such as might have been used for a lower voltage line. A nonresonant type coupler would also have given flatter response across the band, but in that case it must be pointed out that such a coupler would introduce a phase angle for the center frequency (unless it was the only channel using the coupler) which was not present in the tests.

Probably the most favorable results would be obtained by using the large values of coupling capacitance now available with nonresonant couplers, but resonating this capacitance with conventional line tuners.

Results on Field Installation. One channel investigated consisted of three sections, with two by-passes, totaling six sets of coupling equipment. A 2,900-cycle tone, frequency modulated, was sent over the carrier at a deviation designed to produce full audio output from the discriminator. The equipment was pretested to give this output with a 50-db variation in channel attenuation. When installed, however, little or no audio output could be obtained from the receiver. There was a trap at the receiving end behind which was a transformer bank. This bank looked like a capacitive reactance at carrier frequencies and this resonated with the inductive reactance of the trap about 2,900 cycles above its tuned frequency. The result was that the upper 2,900-cycle side frequency was terminated in a near short circuit, and the fact that the cascaded tuning equipment had impaired the other side bands resulted in complete loss of modulation. This example is given to show what can happen to a frequency modulating tone if the channel conditions are sufficiently adverse.

Effects on Amplitude Modulation. Tests were run on the FM transmission since Fillmore's work suggests this would show the most striking phenomena. However, AM, although not so severely affected since the side frequencies do not stretch out so far, is still subject to two effects. If the carrier frequency is chosen in one of the sharp valleys of the attenuation versus frequency characteristic, the side frequencies will be reduced relative to the carrier, so that what started as 100-per-cent modulation may be received as much less. A striking instance of this occurred on a voice channel in a field installation, where a strong carrier signal was received, but only very weak speech could be heard in the receiver. Views on an oscilloscope at the two ends of the channel showed that the modulation had been almost completely removed. A slight shift in carrier frequency then showed that it had been located in a narrow valley of the characteristic.

If the carrier frequency is on a steep slope between a peak and a valley, then the relative amplitude of the two side frequencies will be altered. In an extreme case, to illustrate the principle, one side frequency might be wiped out entirely, and the other raised to equal the carrier. The received signal now consists of two equal frequencies and the envelope detector in the receiver will produce a wave which is far from sinusoidal, as can be shown by Fig. 5. This shows that if the side frequencies are received unequal, distortion will result.

Effects on Single Side-band Transmission. If the carrier is completely suppressed, for each modulating tone there is only a single frequency transmitted. This will be unaffected by phase displacement, which would merely affect slightly the over-all time of transmission. The attenuation of the path due to tuning equipment, mismatches, and absorption of various kinds, will only weaken the signal, and when it arrives at the receiving terminal it will still be a single frequency. If a number of modulating tones are transmitted, their relative amplitudes at the receiving end may be different from what was fed into the transmitter. This could be compensated for by a corrective network or by altering the gain of the tone receivers. But in no case

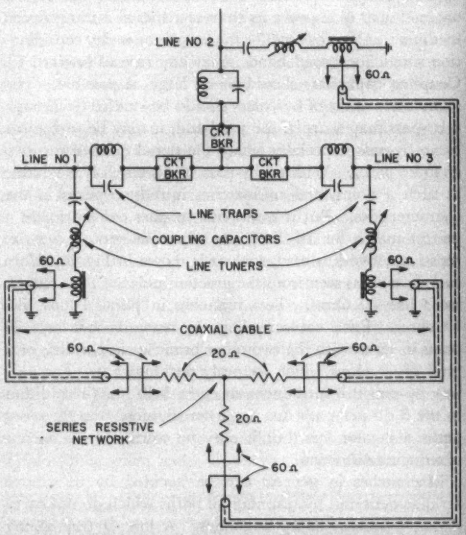


Fig. 6. Series resistive network in 3-way by-pass to obtain proper matching for all directions of transmission

are there any audio harmonics introduced by the action of the transmitting medium.

If some pilot carrier is transmitted, it can be treated as a separate signal. Its relative amplitude may change, but unlike the case with AM, this cannot introduce distortion, since the demodulation process is not envelope rectification, but a mixing action in which a difference frequency is selected.

Comparison of Effects. The above analysis shows that considering the characteristics of the transmission medium, single side band is the most suitable for tone modulation, and both AM and FM, particularly the latter, are subject to distortion and the introduction of audio harmonics. To minimize these and to provide good reproduction for audio frequencies up to 3,000 cycles, the attenuation-frequency characteristic should be flat within 1.5 db over 3 kc for single side-band transmission, 1.5 db over 6 kc for AM, and 1 db over 5 kc for FM with a 2,500-cycle deviation. In addition, for FM the phase angle–frequency characteristic should be linear over 6 kc.[5] This points up one further advantage of single side band in that the bandwidth over which flatness is required is roughly half that for AM or FM.

One advantage of FM should be mentioned: due to the limiter operation the audio output at a given frequency remains constant despite wide variations in strength of r-f signal. However, most tone receivers are capable of giving the same performance over the range of audio input voltage obtainable within the a-v-c range of amplitude modulated and single side-band equipment.

CORRECTIVE MEASURES

Channel Treatment. What may be termed the positive approach to this problem consists of treating the carrier channel so as to improve its characteristics as a transmission medium. All traps used for the frequency under consideration should be broad band, or at any rate of lowered Q. Coupling capacitors should be as large as possible. The cumulative effect of by-passes should be studied—although a by-pass may sharpen the passband, it may be preferable to no by-pass, especially where the signal divides into two or more paths. With no by-pass, a mismatch is inevitable at such a point, and mismatches introduce peaks in the characteristics. But a multipath by-pass can be made a perfect match for all directions of transmission if a series resistive network is used, such as is shown in Fig. 6. Here each branch as seen from the junction point of the network looks like 80 ohms. Two branches in parallel look like 40 ohms. Each cable feeding the network then sees 20 ohms in series with the two other branches in parallel, or a total of 60 ohms which properly terminates it. For a 3-way by-pass this introduces an extra 3-db loss (in addition to the 3 db per path due to power division) and for more paths a greater loss, but it may be worth it as a means of reducing distortion.

Mismatches in general can be avoided by the above arrangement and by trapping all paths which do not carry signal, especially short stub lines. A low Q trap giving about 400 ohms on-frequency will provide a good termination at the receiving point. The receiver input and reverse transmitter output impedance will generally be much higher and not affect the termination. With these improvements, a frequency-attenuation characteristic may show portions which are sufficiently flat over the bandwidth of transmission.

Equipment Selection. If everything possible has been done to secure a flat transmission medium, the next approach is to select the equipment to be used with considerable care, avoiding combinations which are liable to cause trouble. The relative merits of the various types of modulation have already been discussed. Tone frequencies should be selected so as to avoid harmonic relations between the frequencies. Where the tones share the channel with voice, the best method from the tone standpoint is to put the tones in the lower frequency band with the voice above. Voice harmonics then cannot operate the tones. Also the side bands nearest the carrier frequency are less liable to channel distortion than those further removed. On the other hand, any tone harmonics produced by the r-f equipment will be heard in the speech band. For this reason, most modern equipment, which is designed for use on channels which are flat over the transmission bandwidth, arranges the tones above the voice band.

Tones which are keyed or modulated by a frequency shift method appear to be less susceptible to interference from harmonics or other noises in their passband, but on failure of the tone transmitter or the channel, they are just as liable as conventional on-off keyed tones, to false operation. For this reason it is advisable to restrict the use of tones over complex carrier channels, such as those described here, to functions such as telemetering where false operation will not produce serious results. A good alarm system, which will notify an operator as soon as a tone channel fails, is advisable for supervisory and load-control functions.

CONCLUSIONS

The frequency versus attenuation and phase-angle characteristics of power line carrier channels show peaks and valleys which become more pronounced the more complex the carrier path is, due to mismatches, traps, and tuning equipment. This characteristic introduces audio distortion into a voice channel which is least serious for single side-band transmission, but for conventional AM and for FM tends to make tone operation over the channel unreliable. The channel can be improved by avoiding mismatches and using low Q traps, but apart from this the tone frequencies have to be chosen with care to avoid harmonic relationships. Tone applications may be limited to those functions where nonoperation or false operation would not have serious consequences.

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Design of the Adjustable Lin-O-Phase Filter

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ALONG with the growth of power-line carrier communication and consequent crowding of the frequency spectrum between 40 and 200 kc, there has arisen the need for band-pass filters at the carrier receiver input to prevent adjacent channel interference. With FM transmission, performance required of the filters is as follows:

1. Must be adjustable to a frequency from 40 to 200 kc.
2. Maximum midband insertion loss not to exceed 9 db at 40 kc, nor 17 db at 200 kc, and to increase linearly from 40 to 200 kc.
3. Attenuation at frequencies ±8 kc from midband, 100 db minimum below midband loss.
4. Response at frequencies ±3 kc from midband to be within 5 db.
5. Maximum distortion 10 per cent (with 1,000-cycle audio and modulation index = 2.5) when tested with a FM receiver.
6. Response and distortion limits must not be exceeded over a range of temperature from −20 to +70 C, and at humidities up to 95 per cent.

To prevent FM distortion, it is necessary to consider both amplitude and phase response over the frequency range of each filter. In an ideal filter, phase-shift would be linear throughout the passband. Such a filter cannot be realized because of inevitable coil and reflection losses.

Several types of filters have the necessary attenuation, but the m-derived band-pass configuration of Fig. 1 was chosen for the Lin-O-Phase filter because of its simplicity and fairly linear phase-shift over the passband. Linearity of phase shift sufficient to prevent distortion of FM signals transmitted through the filter is indicated by the typical phase shift curve shown in Fig. 2 for 100-kc carrier frequency.

The filter is made adjustable so that it may be tuned to any frequency within the range. A total of 16 different designs covers the carrier band of 40 to 200 kc, with each filter covering about 10 per cent of this band. These filters are all similar in construction and differ from each other only in the values of inductance and capacitance necessary to tune the filter to the desired frequency. Tuning is accomplished by an adjustable slug within each coil. The range over which the coil can be tuned is limited to 25 per cent of maximum inductance in order to maintain the coil Q values necessary to keep insertion loss within the limits.

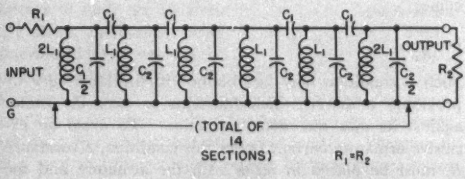

Fig. 1. Lin-O-Phase filter circuit configuration

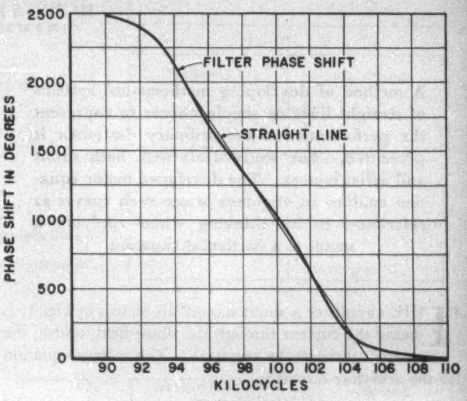

Fig. 2. Typical Lin-O-Phase filter phase shift

Each filter section is completely shielded from each other section. Shielding is necessary because of stray flux from the adjustable coils. (Such shielding is not necessary in fixed frequency filters using toroidal coils; with care in manufacture, toroidal stray flux can be made negligible.) The filter case itself is made of cast iron and has 15 compartments, one for each section. The first and last sections are half-sections for matching purposes. Each compartment is lined with a nonferrous metallic liner to maintain coil Q at a high value. If the nonferrous liner were omitted, stray flux from the coil would cause sufficient loss in the cast iron to degrade Q and exceed the insertion loss limits. If the case itself were nonferrous, stray flux would couple sections together and by-pass the filter.

Distortion was measured with a conventional distortion meter connected in the FM-receiver audio output. Although distortion varied somewhat with carrier frequency, the largest variations occurred with temperature changes. From −20 to +70 C, the distortion varied between 5 per cent and 8 per cent at a given frequency. The most noticeable effect of temperature was to slightly shift the nose of the response curve. With the low-temperature coefficient cores, this shift was approximately ±250 cycles as the temperature was changed from −20 to +70 C. There was sufficient latitude in design that the response remained within limits when temperature varied between extremes.

Digest of paper 55-78, "Design of the Adjustable Lin-O-Phase Filter," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Equations Depicting the Operation of the D-C Motor

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A method of developing mathematical systems of straight lines or simple curves to represent the performance of the ordinary d-c motor is presented. The study deals with both shunt and series motors. The developed motor equation enables an engineer to use such curves as references in his thinking when applying a motor to a particular situation.

THE circuits of a shunt motor* are shown in Fig. 1, I_f being the current through the shunt field, and I_a the current through the armature. The voltage equation for the armature circuit is

$$V=E+I_aR_a \tag{1}$$

where V = the drop in volts from the positive to the negative armature terminals; I_aR_a = the voltage drop in the armature circuit due to the resistance of this circuit; and E = the emf generated in the armature. The equation for the current in armature may be obtained by rearranging equation 1, thus

$$I_a=\frac{V-E}{R_a} \tag{2}$$

Equation 2 may also be written in the familiar form of the straight line equation of analytical geometry, which is $y=mx+b$, where b is the value of y where the curve crosses the ordinate axis, m is the slope, and x is the independent variable. This is shown in the plot of Fig. 2*A*, where x, the abscissa, is the independent variable.

Writing the equation 2 for I_a in the form of a straight line equation gives

$$I_a=\frac{V}{R_a}-\frac{E}{R_a} \tag{3}$$

where V/R_a = intercept (and the current at standstill when $E=0$); $1/R_a$ = slope; emf E = independent variable.

MOTORING

UNDER ordinary conditions of operation for the motor, the generated emf E acts through the circuit in a direction which is opposite to the direction of flow of the armature current, see Fig. 1. Such a condition where the emf acts counter to the current direction results in motor action, the current being supplied by virtue of the fact that the magnitude of E is less than the magnitude of the applied voltage V in equation 2. Referring to Fig. 2*B*, the extent of the magnitude of the armature current in its operating range, is shown by mn, n being the current with the mechanical load removed, and m representing the maximum operating current as limited by the heating of the machine. As shown on the curve the intercept is V/R_a. This is the current at starting without a starting box, and is a non-permissible value for the ordinary motor, being of the order of 20 times or more that of the full load or rated current of the motor. By inserting a resistance R_s in series with the armature at starting, the starting current acquires a practical magnitude being shown by the intercept of the dotted line, to be of a magnitude equal to $V/(R_a+R_s)$.

REGENERATION

UNDER ordinary conditions of motor operation, the value of the emf E does not equal that of the applied voltage V, and the current I_a remains a positive value. During periods of adjustment by field control, if the field flux is increased by lessening the value of rheostat R in Fig. 1, the value of E momentarily will exceed that of V, and the current I_a will decrease or even reverse, and the machine for the time being becomes a generator until its excess kinetic energy has been given up and the speed of the armature has decreased to the equilibrium value, where I_a can give the torque demanded by the load. Such a condition can also be obtained when a motor has its field adjusted so that it pumps power back into the line being driven by another motor or prime mover. In Fig. 2*B* the fourth quadrant represents the regeneration zone, the current I_a reversing at the abscissa intercept r where the value of the emf E equals the value of V, the applied voltage. With further increase of the emf E the current reverses and the motor becomes a generator, the current flowing in the direction of the emf E.

OVERHAULING

REFERRING to equation 2, it is possible for the emf E to reverse its sign and for the machine under this condition to also act as a generator. Thus the equation becomes

$$I=\frac{V+E}{R_a}$$

Such a condition may be obtained in the laboratory by providing a driver which functions to turn the motor against its own direction of rotation. To avoid an excessive armature current under this condition, a resistance R_s must be placed in series with the armature and the

Full text of paper 54-319, "Equation Depicting the Operation of the D-C Motor," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11-15, 1954. Published in AIEE *Power Apparatus and Systems*, vol. 73, December 1954, pp. 1499-1505.

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* The effects of armature reaction are not treated in this article.

operation of the motor in the overhauling range can be depicted by the dotted line in Fig. 2*B*, extending into the second quadrant. A practical example of a motor operating overhauled occurs when a hoisting load is heavy enough to overpower a hoisting motor and drive it against its direction of rotation. The series resistance being adjusted so that an excessive armature current is not obtained. In this case the emf E of the motor acts in the same direction as the applied voltage, with the result that the sum of these two voltages is applied across the total armature circuit resistance, namely; R_a+R_s.

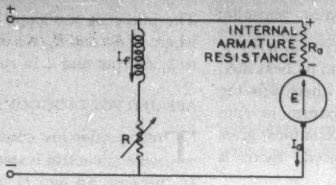


Fig. 1 (above). Shunt motor circuit

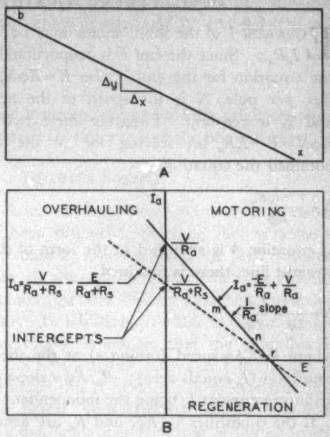


Fig. 2 (right). Equations of straight lines

A—Ordinary straight-line equation; B—Straight-line equation for d-c machine

PLUGGING

In operation both plugging and overhauling represent generator action and are very similar; the emf E being reversed in each case and the current being equal to $I_a=(V+E)/(R_a+R_s)$. In the plugging operation the direction of the emf E is reversed from that for the normal motor operation by a reversal of the armature connection. The connection for this is shown in Fig. 3, the resistance R_s being inserted in the circuit when the switch is thrown to the right for the plugging connection. In the overhauling operation just described, the reversal of E is by contrast obtained by the motor being driven against its normal direction of rotation. In either of these actions, overhauling or plugging, the generated emf E and the supply voltage V both act in additive series, the current being determined by the value of the series resistances R_s and R_a, as shown in Fig. 3. In the plugging operation the generator action serves as a brake, because the motor ordinarily has no driver except that of its own inertia. Plugging is thus used to bring a motor to rest by braking generator action being present during the period of deceleration to zero speed. In Fig. 2*B* the current at zero speed is given by the intercept, this being equal to $V/(R_a+R_s)$. The motor armature will reverse its direction of rotation if the armature is not disconnected from the line, and will accelerate its speed in the opposite direction.

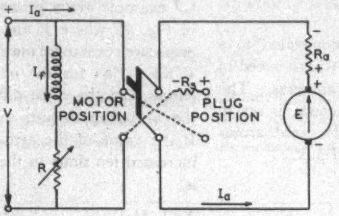


Fig. 3 (above). Plugging connections

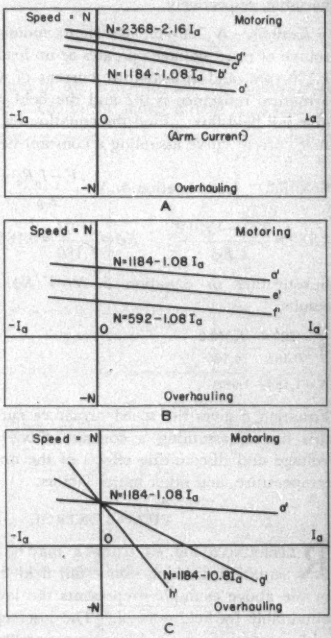


Fig. 4 (right). Graph showing results of different speed-control methods:

A—Field control, adjustable $K\phi$. The $K\phi$ for curve d' is one half that for curve a'; B—Ward-Leonard control, adjustable V. The V for curve f' is one half that for curve a'; C—Armature control adjustable R_a. The R_a for curve h' is ten times that for curve a'

SPEED-CURRENT EQUATIONS

EQUATION 1 of the shunt motor may be written $E=V-I_aR_a$. Since the emf E is proportional to its field flux, the equation for the emf is also $E=K\phi N$, where ϕ is the flux per pole, N is the speed of the armature in rpm and K is constant. Equating these two relations gives $K\phi N=V-I_aR_a$ or, solving for N the speed, there is obtained the equation

$$N=\frac{V-I_aR_a}{K\phi} \tag{4}$$

If equation 4 is arranged in the form of the equation of a straight line, there is obtained

$$N=\frac{V}{K\phi}-\frac{I_aR_a}{K\phi} \tag{5}$$

where $V/K\phi$=speed (ordinate) at the theoretical no-load condition (I_a equals zero); $R_a/K\phi$=slope of the line; the armature current I_a being the independent variable.

If the quantities V, $K\phi$, and R_a are assumed to be constant in any given situation, the relation just developed, equation 5, becomes the equation for a system of straight lines, with I_a and speed N as the independent and dependent variable, respectively.

Example. A 220-volt d-c shunt motor connected to a source of rated voltage operates at no load with a speed of 1,180 rpm, and an armature current of 4 amperes. The armature resistance is 0.2 and the field rheostat is set to give full field flux. Find the equation for the speed–armature current curve assuming a constant field flux.

Solution: Use equation 4, $N=\dfrac{V-I_aR_a}{K\phi}$

$$1{,}180=\frac{220-4\times0.2}{K\phi} \qquad K\phi=\frac{219.2}{1{,}180}=0.186$$

Substituting in equation 5 $N=V/K\phi-I_aR_a/K\phi$, there results

$$N=\frac{220}{0.186}-\frac{I_a\times0.2}{0.186}$$

$$N=1{,}184-1.08I_a \tag{6}$$

Equation 6 gives the speed–armature current equation of this motor, assuming a constant flux, constant applied voltage and discounting effects of the armature reaction, temperature, and other minor factors.

FIELD CONTROL

REFERRING to Fig. 4*A*, Curve a' may be used to represent equation 6 which—since full field flux was assumed in the above example—represents the lowest speed curve obtainable by field control. The intercept is 1,184 rpm, with a negative slope of 1.08 rpm per ampere. A reduction of the field current by inserting additional resistance into the field circuit will result in a smaller value of $K\phi$ with an increase in intercept and slope. As an example, adjustment of the field rheostat so that $K\phi$ becomes one half the value as given in the above equation results in an equation, see Fig. 4*A*, curve d' of

$$N=2{,}368-2.16I_a \tag{7}$$

The intercept and slope become twice their former values, where $V/K\phi$ and $R_a/K\phi$ of equation 7 are equal respectively to 2,368 rpm and 2.16 rpm per ampere.

APPLIED VOLTAGE CONTROL (WARD-LEONARD SYSTEM)

THE equation just considered also applies when armature voltage control is used to vary the speed of the motor. In this case $K\phi$ and R_a are assumed to be invariable, but the applied voltage V, the motor being now essentially a separately excited motor and the armature voltage being separate from that applied to the field, may be adjusted in steps. In Fig. 4*B* assume that the equation of the lower curve with full field is again $N=1{,}184-1.08I_a$. Assume further that the applied voltage of this motor is reduced to 110 volts. The resulting curve now has the equation

$$N=592-1.08I_a \tag{8}$$

The intercept now becomes 592 rpm and the slope remains unchanged from its former value. See Fig. 4*B*, curve e'.

ARMATURE RESISTANCE CONTROL

SIMILAR reasoning with respect to equation 5 and the example given in connection with equation 6 applies to Fig. 4*C* where V and $K\phi$ are invariable and the total armature resistances may be varied in steps. The intercept $V/K\phi$ (1,184 for the example) is common for all of its curves, but the slope differs with each resistance value of the armature circuit, increasing as this value increases. If the value of the armature circuit resistance should be increased ten times in the above example, the new equation is

$$N=1{,}184-10.8I_a \tag{9}$$

The intercept remains the same but the slope is changed to ten times the original or 10.8 rpm per ampere. See Fig. 4*C*, curve h'.

SHUNTED ARMATURE CONTROL

A STUDY of the above general speed equation will reveal that, unless the Ward-Leonard system is employed, the no-load speed cannot be reduced below that of the value for curve a' as shown in Fig. 4, by using either the field method (vary $K\phi$) or by use of the armature resistance control (vary R_a). A method of reducing the speed of a shunt motor without the inherent drastic load speed changes, due to the high slope of the armature resistance control method lies in the shunting of the armature with a resistance (R_p as shown in Fig. 5).

This method, although lacking the fairly high efficiency of the Ward-Leonard system, nevertheless offers a simple and effective approach to obtaining speeds below the basic full-field level of speed with a low value speed change per ampere (small slope).

Referring to Fig. 5, it is apparent that

$$I_a=I_s-I_p=I_s-\frac{V-I_sR_s}{R_p}$$

from which

$$I_aR_p=I_sR_p-V+I_sR_s$$

then

$$I_s(R_s+R_p)=V+I_aR_p$$

or

$$I_s=\frac{V}{R_s+R_p}+\frac{I_aR_p}{R_s+R_p}$$

It is apparent that the voltage E generated in the armature is equal to the applied voltage V minus the drop in the series resistance R_s and that of the armature resistance R_a. This is $E=V-I_sR_s-I_aR_a$. Substituting the value of I_s as found above, there results

$$E=V-\left(\frac{V}{R_s+R_p}+\frac{I_aR_p}{R_s+R_p}\right)R_s-I_aR_a$$

$$=V-\frac{VR_s}{R_s+R_p}-\frac{I_aR_sR_p}{R_s+R_p}-I_aR_a$$

$$=V\left(1-\frac{R_s}{R_s+R_p}\right)-I_a\left(\frac{R_sR_p}{R_s+R_p}+R_a\right)$$

$$=V\left(\frac{R_p}{R_s+R_p}\right)-I_a\left(\frac{R_sR_p}{R_s+R_p}+R_a\right)$$

Writing the speed equation with I_a as the independent variable and using $E=K\phi N$ finally results in

$$N=\frac{V}{K\phi}\left(\frac{R_p}{R_s+R_p}\right)-\frac{I_a}{K\phi}\left(\frac{R_sR_p}{R_s+R_p}+R_a\right) \qquad (10)$$

Equation 10 gives the speed–current equation for a shunt motor operating with a shunted armature resistance and series resistance. It will be noticed that the original intercept $V/K\phi$ is multiplied by a factor which is of value unity or less. Also the armature resistance R_a is effectively increased by a term which is similar to that found if the resistance R_s and R_p should be connected in parallel. If the value of R_p is infinite and that of R_s is zero, equation 10 reduces to that for an ordinary shunt motor, as given for equation 5. The effect of the resistances R_s and R_p may be studied effectively by assuming certain given values for R_s and R_p.

Example: Assume that the shunt motor used in the previous example with full field setting is connected according to a shunted armature connection. What is the speed–armature current equation for this motor if R_s and R_p (Fig. 5) are each set at 2 ohms?

In the previous example, the equation was found to be $N=1{,}184-1.08I_a$ with the following motor values $K\phi=0.186$, $V=220$, $R_a=0.2$. Substituting these values in equation 10 and using $R_s=2$ and $R_p=2$ there results

$$N=592-6.48I_a$$

This gives a speed intercept of one half the original value, with a slope for speed six times that of the original curve.

SERIES MOTOR

UNLIKE the shunt motor, whose speed characteristics have just been discussed, the field flux of a series motor† cannot remain at fixed values as the load changes. Being a function of the load current, the straight-line equations which have just been discussed are not applicable to the series motor. In addition, in order to obtain simple relations, it is necessary to assume that the field flux is proportional to the field current throughout the range of operations. Although this relation is not strictly true it is justified, since a better understanding of the motor is obtained when a mathematical equation is found which shows the relation of each factor to the performance of the motor. Letting $E=K\phi N=V-I_aR_t$ there results a speed equation similar to the shunt motor.

$$N=\frac{V}{K\phi}-\frac{I_aR_t}{K\phi}$$

where R_t is the sum of the armature field and additional series resistance (if used) in the motor circuit R_s, shown in

†In this discussion the field flux is considered to be proportional to the field current.

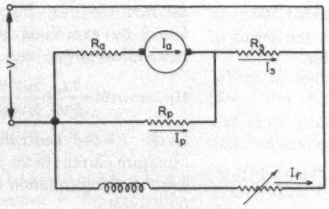


Fig. 5 (above). Shunted armature speed-control connections

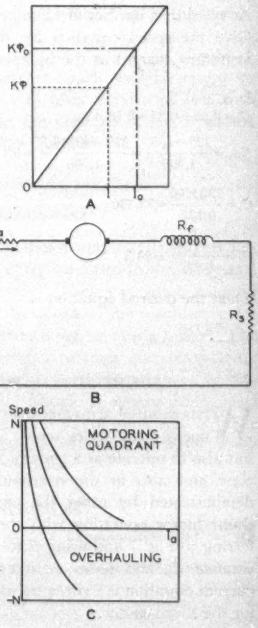


Fig. 6 (right). Series motor:

A—Assumed relation of flux to field current; B—Ordinary connection; C—Typical speed curves

Fig. 6*B*. Referring to the magnetization curve of Fig. 6*A*, the following relation may be given, (I_o is the field current I)

$$\frac{K\phi}{I_a}=\frac{K\phi_o}{I_o} \tag{11}$$

where ϕ_o = flux for any value of field current I_o (in this case also the armature current) where the speed is known. Solving for $K\phi$ and inserting this in the above speed equation

$$N=\frac{VI_o}{I_aK\phi_o}-\frac{R_tI_o}{K\phi_o} \tag{12}$$

which is the speed-armature current equation of the series motor. Since N and I_a are the only variables, this equation may also be written

$$N=\frac{C_1}{I_a}-C_2 \tag{13}$$

where C_1 and C_2 equal respectively the constant terms $(VI_o)/(K\phi_o)$ and $(R_tI_o)/(K\phi_o)$.

A study of equation 13 shows that its plotted curve is made up of an hyperbola and a constant term. The hyperbola represents the speed equation if the circuit resistance of the motor were theoretically zero. The greater the series resistance of the motor, the lower the speed becomes, with any given value of current, as shown by the family of curves. It should be noted that the ordinary series motor is only capable of performance as a motor and as a generator in the overhauling range when the speed becomes negative. Should the armature connections be reversed it will also operate during deceleration in the plugging range.

Example. A 220-volt series motor has an armature resistance of 0.25 ohm, and a field resistance of 0.05 ohm. At rated load current of 40 amperes, the speed is 1,700 rpm. Give the speed equation for this motor in the terms of armature current as the independent variable.

$V=220$ volts

$R_t=0.05+0.25=0.30$ ohm

$$K\phi_o=\frac{220-I_aR_t}{1{,}700}=\frac{220-40\times0.3}{1{,}700}=0.122$$

$$C_1=\frac{220\times40}{0.122}=72{,}130$$

$$C_2=\frac{0.3\times40}{0.122}=98.3$$

Then the desired equation is

$$N=\frac{72{,}130}{I_a}-98.3 \tag{14}$$

SHUNTED ARMATURE CONTROL

With shunted armature control it is possible not only to operate the series motor in the motoring quadrant, but also to operate as a generator, both in the regenerative zone and also in the overhauling zone. This may be demonstrated by using the equation developed for the shunt motor operating with the armature shunted. Referring to Fig. 7 and using R to be the sum of the field resistance R_f and series resistance R_s the speed-armature current equation is written by using equation 10 developed for the shunt motor.

$$N=\frac{V}{K\phi}\left(\frac{R_p}{R+R_p}\right)-\frac{I_a}{K\phi}\left(\frac{RR_p}{R+R_p}+R_a\right)$$

For a series motor $K\phi$ is a function of I_s the field current. Then from the magnetization curve $K\phi=K\phi_o(I_s/I_o)$. Substituting $I_s=I_a+I_p$ and using $I_p=(V-I_sR)/R_p$

$I_s=I_a+(V-I_sR)/R_p$

$(I_sR_p+I_sR)=I_aR_p+V$

This gives $K\phi=K\phi_o/I_a\ [(I_aR_p+V)/R+R_p]$.

If the value of $K\phi$ is now substituted in equation 10 there results:

$$N=\frac{V}{\dfrac{K\phi_o}{I_o}I_a+\dfrac{K\phi_oV}{I_oR_p}}-\frac{(R+R_a)}{\dfrac{K\phi_o}{I_o}+\dfrac{K\phi_oV}{R_pI_oI_a}}-\frac{RR_a}{\dfrac{K\phi_oR_p}{I_o}+\dfrac{K\phi_oV}{I_oI_a}} \tag{15}$$

Equation 15 reveals that a series motor with a shunted armature has a definite speed when the load is zero. With this connection it is also capable of operating with a reversed armature current in the regeneration zone.

If R_p becomes infinite, then the connection for an ordinary series motor results and equation 15 reduces to equation 12, which is

$$N=\frac{V}{\dfrac{K\phi_o}{I_o}I_a}-\frac{(R_t)}{\dfrac{K\phi_o}{I_o}}$$

SPEED TORQUE CURVES

In the preceding comments upon the speed characteristics of motors, the armature current has been taken as the independent variable. In the selection of a motor for a given application the speed–torque curve of the motor assumes a role of importance. The developed torque is found by expressing the electric power converted into mechanical power, thus

$$\text{Hp converted}=\frac{EI_a}{746}=\frac{2\pi TN}{33{,}000} \tag{16}$$

where E = the generated motor emf in volts; I_a = the armature current in amperes; and T = the torque in pound feet. Solving equation 16 for T, and substituting $E=K\phi N$, there results

$$T=\frac{7.04EI_a}{N}=\frac{7.04(K\phi N)I_a}{N}=7.04K\phi I_a \tag{17}$$

SHUNT MOTOR

The speed-armature current relation for the shunt motor has already been developed and is given by equation 5

$$N=\frac{V}{K\phi}-\frac{I_aR_a}{K\phi}$$

Substituting the value of I_a from equation 17 in terms of torque into this speed equation there results

$$N=\frac{V}{K\phi}-\frac{TR_a}{7.04(K\phi)^2} \tag{18}$$

If the quantities V, $K\phi$, and R_a are assumed to be constant then the relation just developed, equation 18, becomes the equation for a system of straight lines with the developed

torque T and the speed N as the independent and dependent variable, respectively. In Fig. 8 as step 1 the field is set and kept constant at a given value $K\phi$ with V and R_a being invariable. The resulting speed-torque curve, for this setting, has an intercept $V/K\phi$ and a slope equal to $R_a/[7.04(K\phi)^2]$. If the field strength $K\phi$ is decreased, the intercept of the curve increases with a slight change in slope. This is shown by the curve marked *2*.

The equation just discussed is also applicable when armature voltage control is used to vary the motor speed. In this case it can be assumed that $K\phi$ and R_a are invariable, but that the voltage V may be adjusted in steps. The family of curves as given here have different intercepts while the slope of the curve remains unchanged Fig. 8*B* with the adjustment of the voltage V.

If the armature resistance is varied in steps with V and $K\phi$ remaining invariable for each step, a series of straight lines result. This is shown in Fig. 8*C*, the intercept being common for all the curves, but the slope of each increasing with increased armature resistance.

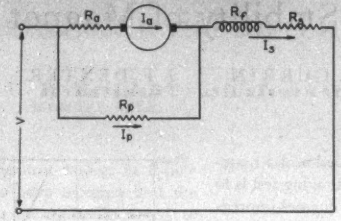
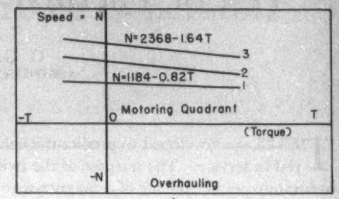
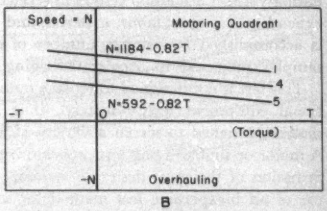


Fig. 7 (above). Series motor with shunted armature





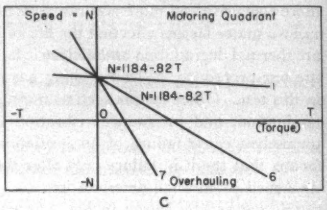


Fig. 8 (right). Speed–torque curves:

A—Field control, adjustable $K\phi$; B—Ward-Leonard control, adjustable V; C—Armature control, adjustable R_a

Example. Assuming that the shunt motor previously discussed is considered, the equation was found to be $N=1{,}184-1.08I_a$. Since $K\phi$ was found to be 0.186, the equation for the torque becomes $1{,}184-0.821T$. This is shown in Fig. 8*A*. The curves shown in the remaining Figs. 8*B* and 8*C* demonstrate the equations that result from varying V and also R_a.

SHUNTED ARMATURE, SHUNT MOTOR

THE speed–torque equations for a shunt motor with this type of connection is found in a manner similar to that for equation 18. The speed–armature current equation for a shunted armature has already been found by equation 10 to be

$$N=\frac{V}{K\phi}\left(\frac{R_p}{R_s+R_p}\right)-\frac{I_a}{K\phi}\left(\frac{R_sR_p}{R_s+R_p}+R_a\right)$$

Substituting the value of $I_a=T/7.04K\phi$ from equation 17 there results

$$N=\frac{V}{K\phi}\left(\frac{R_p}{R_s+R_p}\right)-\frac{T}{7.04(K\phi)^2}\left(\frac{R_sR_p}{R_s+R_p}+R_a\right) \qquad (19)$$

If the motor resistance flux and applied voltage is kept constant, this is an equation for a straight line of the form

$$N=C_1-C_2T$$

where C_1 and C_2 are constants which may be found by inspection of equation 19. Finding these constants with the same motor as used in the previous example for the shunted armature, when $R_s=2$ and $R_p=2$

$$N=592-4.92T$$

CONCLUSIONS

THE previous discussion demonstrates that simple mathematical curves can be effectively used in the study and application of the d-c motor. They can serve a useful purpose in understanding the action of the machine under conditions of motoring, regenerating, or overhauling. The relations may also be extended to show the determining factors of operation with special control connections, such as armature or field shunting. Simple equations using speed and torque as the variables for a motor are valuable, since mechanical loads are commonly expressed in terms of the same variable.

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Test of Thermal Stability of Magnet Wire Enamel

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TESTS are developed to predict the behavior of a material in service. The purpose of the twist aging test is to accurately predict the life of a magnet-wire enamel-impregnating-varnish insulation system in service with a minimum expenditure of time, labor, material, and equipment. This is accomplished by using a number of easily constructed samples subjected to accelerated aging and evaluation.[1]

This test is not designed to replace motor or similar functional equipment tests. Instead, it is a laboratory test method designed to screen a variety of insulation systems. A motor or similar aging test program is then used for confirmation of the most desirable system. This permits the use of an inexpensive test method for screening, and the more expensive and more accurate tests for final evaluation.

Two major factors affecting the life of insulating systems are thermal degradation and dielectric fatigue. To simplify the test procedure, dielectric aging has not been included in this test. Other factors such as moisture, chemical contamination, and mechanical vibration usually do not in themselves cause failure of an insulation system, but are factors that result in failure only after the system has been weakened by thermal deterioration.

The test sample shown in Fig. 1 is a standard National Electrical Manufacturers Association dielectric strength twist of the enameled wire, reinforced for mechanical strength, identified, and impregnated with an electrical insulating varnish.

The samples are aged at several temperatures. The life-temperature relationship is then established over a temperature range. This relationship[2] is the goal of the test and from these data the life at lower temperatures can be predicted.

Since the primary purpose of magnet-wire enamel is to serve as a dielectric barrier, the over-all effectiveness of the enamel may be determined from the dielectric properties. Any fault in the dielectric barrier of the enamel film which would cause an apparatus to fail may be detected by a decrease in the dielectric strength of the enamel. Dielectric strength is one dielectric property which is accurately and easily measured. This is the functional and practical basis for selecting dielectric strength as a criterion for enamel failure.

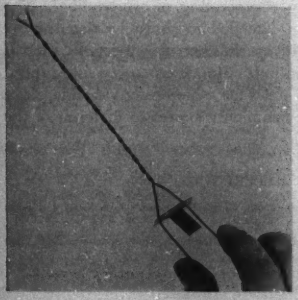

Fig. 1. Typical test sample

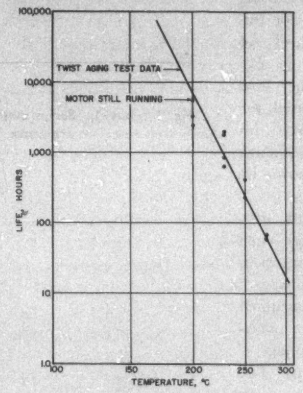

Fig. 2. Comparison of results on modified silicone enamel by twist aging tests and a motor aging test. Points indicate lives of 10-hp 1,200-rpm 3-phase 440-volt 284-frame induction motors

For simplicity, the test voltage is applied for only 1 second and is applied periodically during the aging of the twists. When all the samples have failed, the average life at the particular aging temperature is determined. The life–temperature characteristic may then be plotted.

Factors of this test method which have been studied are: sample preparation methods; effect of varnish impregnation; effect of thickness of varnish film; failure criteria; effect of moisture conditioning; effect of wire size; reproducibility of results; effect of thermal shock; aging temperatures; and number of samples required.

The twist aging method is of value only if there is close correlation with the results obtained by the more functional motor tests. Motor aging tests have been recognized as an accurate basis for estimating insulation life.

Correlation has been found between the twist aging test of polyvinyl formal insulated magnet wire and published motor aging tests, and one coil aging test. Fig. 2 shows very close correlation between the twist aging test and a motor aging test[3] on a modified silicone enamel.

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Field Conductor Material for Turbine Generators

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THE present demands for large unit ratings in 2-pole high-speed turbine generators have dictated that the field-winding conductor materials be unusually strong to withstand the various mechanical stresses applied during the operation of the machine. At the same time, high electrical conductivity must be maintained so that the material can be most efficiently utilized.

In the past, field conductor distortion has been one of the limitations in designing a thoroughly reliable large turbine-generator field. Conductor distortion results from a cycle beginning when the generator starts to rotate after a shutdown. At this time, the field conductors, which are cold, are thrown outwards by centrifugal force and being restrained by the wedges gradually become locked in by this force at approximately 2/3 rated speed. When synchronous speed is reached, field current is applied, the generator is connected to the system, and load is picked up. During this increased application of field current, the conductors heat up and attempt to expand. However, since they have previously been locked in, as a result of the centrifugal force, the thermal expansion is restrained and a resulting compressive stress is applied to the conductors. At these elevated temperatures (hot spot temperatures may vary from 100 to 140 C), the compressive stress applied may cause plastic deformation if

1. The stress exceeds the elastic limit of the material as defined by the compressive stress-strain curve at operating temperature.
2. The high loadings obtained at these temperatures exceed the compressive creep strength of the material.

Each of these phenomena may produce a minute but significant upsetting in the conductor material. As this cycle is repeated, beginning from a cold start, the upsetting is again introduced and the effect is additive.

Conductor distortion as shown in Fig. 1 has been pronounced on field windings made with annealed tough-pitch copper and annealed electrical conductivity (E.C.) grade aluminum.

Fig. 1. View of end winding conductor distortion showing lower turns of coils pulled in towards field body

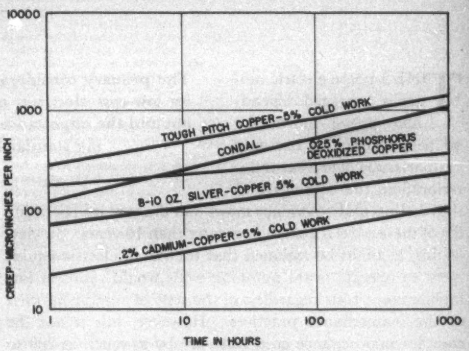

Fig. 2. Compression creep of some coppers and Cond-Al at 140 C and 8,000 psi

A 2-step development program to produce the required field conductor materials was initiated as follows:

1. An intensive test program to determine the physical properties, including compression creep at elevated stresses and temperatures, of commonly used field conductor metals and those developed under item 2 below.
2. The development of high-conductivity copper and aluminum alloys with a compressive yield strength of 12,000 pounds per square inch (psi) or better at 140 C and with negligible creep at this loading and temperature.

The results of this program have been encouraging.

Silver and cadmium bearing coppers are now available and in use that have compressive yield strengths at 140 C of about 20,000 psi, or more than 3 times that of annealed tough-pitch copper. These alloys undergo less than 2 per cent the amount of deformation in compression creep of annealed tough-pitch copper at stress levels existing in generators with no sacrifice in electrical conductivity.

An aluminum alloy "Cond-Al" is in commercial use which has a compressive yield strength at 140 C of 15,000 psi or about 4 times that of annealed E.C. aluminum. Cond-Al suffers less than 1 per cent as much deformation in compression creep as annealed E.C. at machine stress levels, and 10 per cent the creep of E.C. which has been 20 per cent cold worked and stress relieved. The electrical conductivity of Cond-Al is within 2 per cent of E.C. aluminum. Typical creep curves of these materials are shown in Fig. 2.

Digest of paper 55-131, "Improved Field Conductor Material for Turbine Generators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1955. Scheduled for presentation in AIEE *Power Apparatus and Systems*, 1955.

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Maintenance of Electric Beam Pumping Equipment

T. L. SCOTT

The primary considerations for obtaining quality low-cost electrical maintenance are pointed out and the importance of technical and operating standards are stressed.

THE 3-phase electric motor is a rugged dependable prime mover for oil field service. It has only two parts subject to wear or deterioration, the bearings and the winding, and experience shows that the average operating life of these parts is generally greater than 10 years. In view of this, it might be assumed that the use of electric equipment to operate beam pumping wells would result in low maintenance costs regardless of the type of equipment used or the maintenance practices. However, this is not the case, for maintenance costs can vary by as much as 200 to 300 per cent. To illustrate this, the electrical maintenance costs by two different areas are presented.

Area 1. This area consists of 167 beam pumping motors, 44 transformer banks, and 42 miles of line. All installations conform with present company standards. The average motor age is 4 years. During the last 8 years, the area has accumulated 668 motor operating years with three winding failures. The present average maintenance cost for motors, controls, service connections, lines, and transformer banks is $3.25 per month per motor. Included in this maintenance cost are material, labor, and transportation.

Area 2. This area consists mainly of older nonstandard electric installations. Climatic conditions are similar to those in Area 1. During a recent period of 30 days, six motor winding failures occurred, at an approximate cost of $725.00. Five of the failures were due to lightning, and one of the failures was due to a stalled single-phase condition. The six motor failures represent approximately 1 per cent of the total beam pumping motors in the area. In 1944, the motor winding failures due to lightning were more than 15 per cent of the total motors installed. In 1945, the percentage was again over 15 per cent. Since 1945, there has been a continuous program of lightning protection improvement which has reduced the annual failures to 3 or 4 per cent. The electrical maintenance costs for this area are approximately $6.30 per motor per month.

Though the difference of $3.05 in monthly motor maintenance costs for the two areas may appear to be small, it becomes a very significant figure when the annual maintenance cost for 1,600 beam pumping motors is considered. On the basis of costs in Area 1, the annual maintenance cost for 1,600 motors would be $62,400, and on the basis of costs in Area 2, the annual maintenance cost would be $121,000.

The question may now be asked, "How can better electric motor operation be obtained with reduced cost?" Quality low-cost maintenance is primarily dependent upon:

1. Selection and installation of equipment.
2. Measurement of maintenance requirements.
3. Organizing and scheduling of maintenance operations.

Before maximum cost reductions can be effected, particular consideration must be given to the preceding factors and all the activities related to low-cost maintenance must be co-ordinated. Complete discussion of all the maintenance factors is beyond the scope of this article, and the following is only a brief approach to the problem of low-cost maintenance.

SELECTION AND INSTALLATION OF EQUIPMENT

THE electric beam pumping installation consists of transformer bank, lines, service connections, controls, and motors. It is only necessary to check a few of these installations before concluding that there is considerable variation in the selection and installation of electric equipment. This variation is not only prevalent between companies but within companies. To the person not familiar with electric operations, it might be assumed that the practice of carefully selecting and installing electric equipment was of little importance. However, this practice is very important, for trouble-free low-cost electric operation begins with proper selection and installation of equipment.

With the extensive operations of most oil companies, control of electric installations can only be achieved through the use of standard specifications. The use of standard specifications has resulted in lower maintenance costs. Standards are also of value when bids are being solicited for electrical work.

It would be very difficult to evaluate each standard and particularly the value of the lightning protection standard. However, a review of the motor failures due to lightning in Area 1 and Area 2 may be of interest and value.

Location	Annual Motor Failures Due to Lightning (Per Cent of Total Motors)
AREA 1	
With standard protection	0.45
AREA 2	
With nonstandard protection	3.00 to 4.00
With no protection	15.00

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The author wishes to acknowledge the help received from M. H. Halderson and D. M. Clark.

It should be pointed out that the frequency of thunderstorm days per year is approximately the same in the two preceding areas. The isokeraunic map shows the prevalence of lightning storms to be 35 thunderstorm days per year in Area 1 and 40 thunderstorm days per year in Area 2. Because the isokeraunic map does not show the magnitude or duration of the thunderstorms, a direct evaluation of the value of the lightning protection standard cannot be made on the basis of the motor failures in Areas 1 and 2. However, the negligible number of motor failures in other areas where the installations are standard and the thunderstorm frequency is 40 or more, suggests that the lightning failure records of Areas 1 and 2 are a substantial indication of the value of the standard lightning protection.

Another example of the value of standards occurred in Wyoming when a stalled single-phase condition occurred in an area where there are 31 motor installations. All but two of the installations had controls which were wired according to the standard that specified that the time delay–relay coil will be wired across a different phase than the magnetic starter holding coil for stalled single-phase protection. The results in Wyoming? The two motors with nonstandard wiring of the controls burned up.

MEASUREMENT OF MAINTENANCE REQUIREMENTS

Effective inventory control of perishable material for a processing plant is essential to efficient operation. Inadequate control results in costly material waste and production delays. Maintenance labor might also be considered a perishable material, for here too, inadequate control results in costly waste and production delays, and money once spent for wasted labor or poor work can never be regained. Hence, for efficient operations, maintenance labor must be balanced against the actual work requirements.

The maintenance requirements are determined by either direct-method analysis or on the basis of previous analyses and studies. The same approach is also used in selecting transportation units, tools, and equipment necessary for the efficient performance of work.

The maintenance requirements for electric-beam pumping equipment in Area 1 are shown in the following tabulation. Area 1 has the following motors: 1—2 hp; 13—5 hp; 27—7½ hp; 77—10 hp; 31—15 hp; 4—20 hp; 8—25 hp; and 6—30 hp. There are 44 transformer banks and 42 miles of line. Preventive maintenance checks are performed twice a year on motor installations and once a year on lines and transformer banks. Radius of operations is 50 miles. Table I shows the requirements representative of good operations, but they are not the lowest obtainable.

On the basis of the preceding maintenance requirements for Area 1, one electrician could take care of 272 beam pumping motors, 72 transformer banks, and 69 miles of line where conditions were similar.

At the present time, all motors in Area 1 are given a preventive maintenance check twice a year. This frequency is to be changed to once a year for motors of 20 hp and less, and on this basis one electrician, where the conditions were similar to Area 1, could take care of 338 motors, 89 transformer banks, and 85 miles of line. This change will also reduce the maintenance cost from $3.25 to approximately $2.76 per month.

Table I. Actual Maintenance Requirements for Electric Beam Pumping Equipment in Area 1 (Based on Actual Work Performed for a 5-Month Period)

Job Classification	No. Jobs	Man-Hours	Mileage
Preventive maintenance checks	378	567.0	5,292
Time delay relay repairs	39	74.1	780
Checking and replacing overload heaters	12	28.8	378
Repair and replacement of overload relays	3	12.0	117
Replacement of meter protectors	3	9.0	138
Repair and replacement of time clocks	7	10.5	133
Replacement of surge capacitors	1	1.8	35
Replacement of circuit breakers	2	6.0	64
Repair and replacement of selector switch	2	4.0	32
Repair of magnetic starters	3	8.1	108
Starter connection work	2	4.4	52
Repairing and checking of grounds	6	7.8	108
Service repair and revision	2	12.0	148
Electrical measurements and testing*	14	21.0	406
Motor winding failures	1	8.0	82
Motor bearing replacements	13	75.4	468
Motor cleaning	6	12.0	148
Replacement of motor sheaves*	27	59.4	810
Replacement of service pole arresters	5	10.0	230
Re-fusing	34	88.4	1,054
Line repairs	8	43.2	336
Transformer bank repairs	3	24.0	255
Receiving calls and posting records	260	78.0	0
Checking tools and replacing equipment	26	26.0	130
Total	857	1,190.9	11,304

Maintenance Cost per Motor per Month = $\frac{\$6,517.84}{167 \times 12} = \$3.25$

Note: One electrician takes care of the electrical work in Area 1 and two adjacent areas which were not covered by this tabulation.

* Not ordinarily considered electrical maintenance.

ORGANIZING AND SCHEDULING MAINTENANCE OPERATIONS

After a carpenter has carefully measured a board for cutting, he must be able to saw the board to dimensions or his measurements will have been of little use. This problem is similar; after the electrical maintenance requirements have been determined, it must be possible to organize and schedule the work on the basis of these measurements. In doing this there are three main considerations:

1. Scheduling of work.
2. Organizing a communications system for requesting work.
3. Instructions and standard practices.

Oilfield electrical maintenance can be divided into three types of work: (1) repetitive work (preventive maintenance checks and lubrication), (2) scheduled repair work, and (3) emergency repair work. Generally, 65 to 95 per cent of the work can be scheduled, and at least 50 per cent of the jobs are of the repetitive type which can be permanently scheduled.

In setting up the system of scheduling work, the object is to design a system that will have flexibility and a system that will not be seriously affected by the performance of repair and emergency jobs. This may be accomplished in the following manner:

1. Each permanently scheduled job is assigned a number. This number shows the order in which the jobs will be performed and determines the electrician's path of travel.
2. The repetitive type of work is then scheduled for 3

or 4 days per week. The jobs are scheduled numerically and not by time.

3. Repair jobs that can be scheduled are accumulated and performed on those days when repetitive jobs are not scheduled.

4. The repetitive job schedule is not critical and may be interrupted for short intervals and continued when the accumulation of repair jobs and emergency work makes it necessary. However, if the repair and emergency work is considerable, contract electricians are used.

5. Our system of maintenance is now flexible and similar to a chain in that chain links can be added or the chain can be broken and reconnected without greatly reducing the value or the strength of the chain.

The job order system is essential to work scheduling. With this system, repair work is requested on a job order form on which is provided space for location of equipment to be repaired, brief description of trouble, priority of work, and pertinent information such as parts needed and cause of trouble when this information is available. The work is then scheduled according to its importance.

Much of the oilfield electrical maintenance is of a repetitive or similar nature which permits the maximum use of standard maintenance procedures and instructions. The use of standard practices has been particularly advantageous as it has improved the quality of maintenance work, reduced supervisory requirements, and simplified the training of men.

To further substantiate the value of standard practices, some of the lubrication procedures previously recommended or practiced by electricians and supervisors are presented:

1. Dismantle motors once a year and repack bearings by hand.
2. Grease motors once every 3 months.
3. Use lubricant prepared by electrician.
4. Never grease motors.

It would appear that variety is the spice of lubrication as well as life.

Digital Computer Plug-In Units and Associated Equipment

J. N. HARRIS F. L. McNAMARA

A line of small plug-in units for digital computer systems is described. The unit plugs into a standard 32-contact receptacle; 15 units of these are contained in a subrack assembly. The subrack has self-contained power wiring and a switch for marginal checking. Logical connections are made on a panel by patch cords and miniature spring-loaded connectors.

A FEW years ago most electronic computing systems used analogue techniques. Although these techniques are still valuable for many applications, certain classes of problems have arisen requiring accuracy and complexity which are satisfied more easily with digital techniques. Familiar examples are found in the processing of large volumes of statistical data and the accurate control of complex military and industrial equipment.

Analogue circuits generally require extensive use of variable controls for gain, feedback, frequency, balance, etc., whereas digital equipment is made from a few basic circuits whose states are distinguished by being either "off "or "on"—a modest requirement. These circuits are interconnected in a particularly simple manner. In spite of this simplification, some digital systems still use wiring and assembly techniques borrowed from analogue systems.

Equipment has been developed at Lincoln Laboratory which meets certain needs of digital computer designs particularly well. This equipment consists of a few well-designed basic circuits constructed on small plug-in etched circuit boards. A subrack, constructed on a $4\frac{3}{8}$-inch vertical module, contains receptacles for 15 of these plug-in units and has complete power wiring as well as a front panel where all logical or signal connections to the units are available and which may be interconnected at will by a series of small plug-in jumpers. These subracks may be fitted into a standard relay rack or into the special cabinet which is provided. This cabinet contains a power distribution system, filament supply and control, forced-air ventilation, and a marginal checking power supply. A

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The research was supported jointly by the U. S. Army, Navy, and Air Force under contract with Massachusetts Institute of Technology.

Acknowledgement and deep appreciation is expressed to the many people in the Lincoln Laboratory who contributed valuable ideas during the design of this equipment.

special composite power supply, providing all necessary voltages, completes the system.

CIRCUIT DESIGN

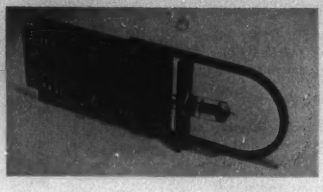
In designing the circuits, advantage was taken of the large amount of work and experience in circuit design at the Massachusetts Institute of Technology Digital Computer Laboratory (DCL). In many cases only slight modifications of their standard circuits were necessary. (DCL logic levels are +10 and −30 volts; the logic levels are 0 and −30 volts.) The circuits were designed to operate from the following direct voltages: +250, +150, +90, −30, −150, and −250 volts. By having a number of potential levels available, power dissipation in bleeder circuits was reduced and it was not necessary to employ special or trick circuits in any design.

The circuits were designed to operate over a range of individual voltage variation of at least ±10 per cent and an even wider range of proportional variation of all voltages simultaneously.

Since high reliability is of prime importance, high-quality components were used whenever possible. This automatically eliminated some interesting, but untested, subminiature components. Whenever advantageous, precision 1-percent resistors were used to increase both the rating of the unit and its margins of reliability. Silver mica capacitors were used only when stability of capacitance was necessary, and then with adequate direct voltage derating to cope with the silver ion-migration problem. For larger capacitances, hermetically sealed paper-foil units were used. Pulse transformers were also hermetically sealed.

Most circuits have been designed using three tube types—*5965*, *5687*, and *7AK7*. These types have satisfied most circuit requirements while keeping the variety of tubes small. In all designs, conservative ratings of the tubes are followed. In many cases the transconductance of the tube may deteriorate considerably before the operation of the circuit is impaired. The choice of these tubes was partially based on the considerable experience of the DCL group in testing and using these tubes in practical digital-type circuits.

Also included in the circuit design is a marginal check arrangement. Marginal checking is an operation which places successively higher and lower than normal voltages at specific points in the circuit. The voltage at which a predetermined test program does not go through the unit or computing system is indicative of the condition of the units being marginal checked. The success of this test depends on the judicious choice of circuit points which are checked. Proper application of marginal checking procedures allows an efficient program of preventative maintenance to be set up, thus increasing the total "on" time of the computing system. A considerable amount of study on this subject already has been carried out by the group at DCL.



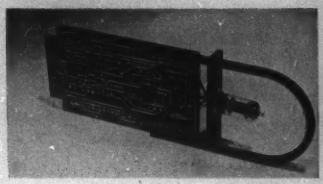


Fig. 1 (left). Component side of low-speed flip-flop. Fig. 2 (right). Back of low-speed flip-flop showing etched circuit wiring

CONSTRUCTION

1. Basic Units. Etched wiring is used throughout in the construction of the basic units. The circuits are made on 1/4-inch thick phenolic material for the following reasons:

1. The Amphenol Blue Line receptacle makes a superior printed-circuit connector.
2. The ruggedness of the 1/4-inch circuit board appeals to users of the equipment.
3. The capacitance between wiring on opposite sides of the board is reduced.
4. Special components and hardware may be mounted by using tapped holes.
5. Dip soldering will not warp the board. There is, of course, the disadvantage of fabrication, particularly the drilling of many small holes. At present, the advantages of 1/4-inch base material seem to far outweigh the disadvantages.

Figs. 1 and 2 show the construction of a typical unit—the low-speed flip-flop. The circuit is on 1/4-inch thick phenolic board $3^{7}/_{8}$ by 7 inches. Eyelets are used to carry wiring from one side of the board to the other and are also used at all points where component leads are connected. The tube socket is mounted on a 1- by $3^{7}/_{8}$- by 1/4-inch dural panel. At the opposite end of the circuit board are terminal tabs for external signal and power connections. A bail, bent from 1/4- by 1/4-inch dural rod, serves as a handle for carrying, hanging, or handling the unit in the subrack.

A lumped constant delay of 1.5 microseconds, tapped every 0.1 microsecond, is shown in Fig. 3. Note that a double width of 2-inch panel is used in this unit to accommodate the larger components. The same is true of circuits using loctal or octal tubes.

A general-purpose high-speed diode matrix is shown in Fig. 4. Other standard circuits such as gates, cathode followers, buffer-inverters, pulse generators, blocking oscillators, etc., have been constructed. In addition, many special units were developed and built using the same construction technique even though only a few were required. This was because of the considerable advantage of physical uniformity.

All standard units are color-coded for quick identification. The color of the panel represents the main classification such as, *black* for flip-flops, *green* for gates, etc. The color

Fig. 3 (left). Tapped lumped constant delay line (1.5 μs)

Fig. 4 (right). High-speed diode matrix with associated cathode follower output

Fig. 5 (left). Subrack complete with plug-in units and front panel wiring. Note plug-in neon indicators and marginal check switch on far right. Fig. 6 (right). Subrack in process of assembly showing space behind front panel for power wiring. Note etched circuit power distribution busses. Short wires connect the signal terminals of receptacles to the front panel jacks

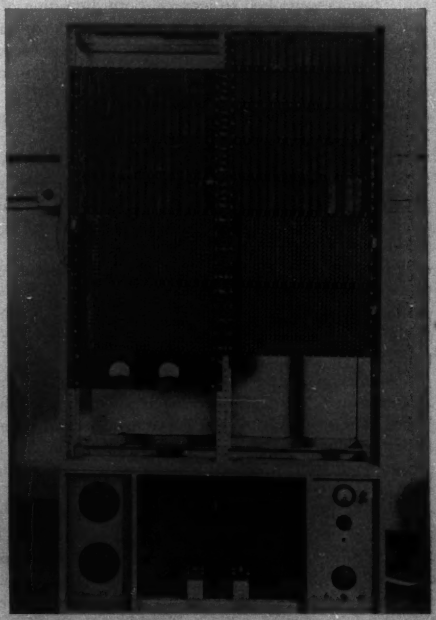


Fig. 7 (left). Rear of cabinet showing mounted subrack and main power distribution. Fig. 8 (right). Front of cabinet. Bottom, left to right—filament controls, dual centrifugal blower, and marginal check power supply

of the bail represents subdivisions as, *red* for the low-speed flip-flop, *green* for the high-speed flip-flop.

2. Associated Equipment:

A. *Subrack.* Views of the subrack are shown in Figs. 5 and 6. The subrack contains guide rails for aligning the units properly when it is inserted and ventilating slots which allow a stream of cool air to be forced over the components in a very efficient manner. A receptacle casting has openings which accept the Blue-Line receptacles and is fastened between the top and bottom castings about $1^1/_2$ inches back from the front of the subrack.

Fifteen phenolic panels are mounted on the front of the subrack. Each panel is associated with a given receptacle and has 16 pairs of Hubbell, type *B*, eyelets in a staggered array. In practice, short jumpers (color-coded by length for easy selection) and having Hubbell, type *B*, spring-loaded plugs at each end are plugged into the appropriate eyelets to make connections between units. D-c power is distributed by means of etched wiring busses on long phenolic strips secured against the top and bottom castings. These may be seen in Fig. 5. Two heavy bus-wire pairs, supported on insulated mountings within this wiring space, carry the filament currents. The power wiring is terminated at a male connector at the rear of the subrack.

B. *Cabinet.* Although the subrack may be held in a standard relay rack when desired, a special cabinet has been designed for maximum utility and saving of space. A view of the cabinet with mounted subracks is shown in Fig. 7. The cabinet may contain up to 24 subracks in two parallel columns. Fig. 8 shows a front of the cabinet. Analogue equipment may also be mounted in the cabinets as long as care is taken to maintain the ventilation scheme.

Power is distributed to the subracks through an aluminum channel which has a cover plate containing 24 evenly spaced connectors located at the center rear of the cabinet.

A dual low-speed (1,725 rpm) centrifugal blower of 2,000-cubic-feet-per-minute capacity is mounted in the bottom of the cabinet. The intake is through a spun-glass filter mounted in the floor of the cabinet. One air stream is through the ventilating slots in the subracks and past the mounted components. Another air stream is directed into the space occupied by the vacuum tubes. These twin air streams combine at the top and exhaust through a grill on the top of the cabinet.

The bottom left of the cabinet contains the filament supply for the cabinet. Two 75-ampere 12.6-volt a-c transformers are controlled in their primaries by Variacs. One filament voltage is biased at a d-c level of -30 and the other at -150 volts. This permits a large variety of circuits to be accommodated without exceeding the heater-to-cathode rating for the tubes.

The marginal check power supply is located in the bottom right of the cabinet. It consists of a d-c power supply and a multiposition switch. The output of the power supply may be switched in series with any one of four voltages which have been selected for marginal checking. This voltage may be varied over a range of ± 100 volts. A very large bleeder current in the output of the power supply allows a $\pm$ variation of both positive or negative voltages.

APPLICATIONS AND CONCLUSION

Several digital computing systems are being built using the equipment described in this article. The results to date have been quite satisfactory. In particular, the facility with which units may be replaced and logical connections between them modified has saved a large amount of time. This saving in time allowed many modifications to be tried which might not have been possible with slower methods of assembly and wiring.

Once a store of basic units and associated equipment is on hand, the assembly of a system requires little time, thus leaving more time for testing new ideas. Also, the duplication of a system becomes a particularly simple matter. Field modifications of the system which may be required from time to time are accomplished in a straightforward manner. In particularly difficult trouble-shooting operations it becomes easy to isolate complete blocks of the system by removing a few jumpers from the front panels.

REFERENCE

1. Marginal Checking as an Aid to Computer Reliability, N. H. Taylor. *Proceedings* Institute of Radio Engineers, New York, N. Y., vol. 38, no. 12, Dec. 1950, pp. 1418–21.

Closing Device for Circuit Breakers Uses Carbon Dioxide

A new type of circuit breaker closing device which uses liquid carbon dioxide as the source of closing power has been announced by the General Electric Company's medium voltage switchgear department at Philadelphia, Pa.

The new equipment, designated as the "Cooperator" closing device, operates independently of the regular source of control or closing power in a station. It is portable and has adequate power to close the breaker against fault currents equal to its full momentary rating.

The "Cooperator" has a standard 10-pound bottle of carbon dioxide as a source for stored energy, a regulating valve, an intermediate receiver for holding the required amount of carbon dioxide gas for each closing operation at about 220 pounds per square inch, a control valve which releases the gas from the intermediate receiver to close the breaker, and a power cylinder and piston for closing the circuit breaker arranged to be placed under the circuit breaker closing solenoid plunger.

Up to 75 closing operations are obtainable from a single standard bottle of liquid carbon dioxide. A reserve bottle is included to assure a full supply at all times.

The device will close all current designs of magne-blast circuit breakers in the interrupting range from 100 to 500 millivolt-amperes as used in both indoor and outdoor metal-clad switchgear.

Development of the RCA 21-Inch Metal-Envelope Color Kinescope

H. R. SEELEN H. C. MOODEY D. D. VANORMER A. M. MORRELL

This article describes the major features of the Radio Corporation of America (RCA) 21-inch metal-envelope color kinescope, and discusses considerations involved in the choice of the size and construction used. Description of a new phosor application method and a discussion of a number of factors affecting register are included.

SOME of the main technical features of the recently announced *21-AXP22* formed shadow-mask color kinescope are presented. The tube with its round metal envelope is shown in Fig. 1. The picture size of 260 square inches is obtained with an over-all tube length of less than 25½ inches. This was made possible by the use of a short gun and a deflection angle of 70°. The spherical faceplate, upon which the phosphor screen is deposited, is of 77-per-cent-transmission gray glass for high contrast under ambient light operation.

A comparison of the physical dimensions of this tube with those of a popular 21-inch black-and-white tube may be of interest. Table I gives the picture and over-all tube dimensions of the *21ZP4-B* and the *21AXP22*. The color tube has a somewhat greater picture size. The height of the round tube is, of course, greater than that of the rectangular *21ZP4-B*; however, its diameter falls between the horizontal and diagonal dimensions of the black-and-white tube. The 2-inch difference in over-all length is taken up entirely in the neck portion. The longer neck of the color tube is necessitated not by gun length, which is about equal in the two tubes, but by the space requirements of circuit components used on the neck of the tube.

Table I. Comparison of Tube Dimensions

	Black-and-White Kinescope, Type 21ZP4-B	Color Kinescope, 21AXP22
Picture dimensions (min.):		
Area	245 sq. in.	260 sq. in.
Width	19⅛ in.	19⅜ in.
Height	14⅜ in.	15¼ in.
Tube dimensions (max.):		
Width	20⅝ in.	...
Height	15¹¹⁄₁₆ in.	...
Diagonal or diameter	21¹³⁄₁₆ in.	20¹¹⁄₁₆ in.
Over-all length	23¹⁵⁄₁₆ in.	25⅝ in.
Deflection angle (diagonal)	70°	70°
Weight	24 lbs.	28 lbs.

Fig. 1. Color kinescope RCA 21AXP22

Shown diagramatically in Fig. 2 is a cross section of the tube. The chrome-iron shell is made in two pieces having matching flanges which are joined by inert-gas welding in the final bulb-sealing operation. The "top cap" consists of the faceplate sealed to the rim portion, within which is mounted a light frame supporting the formed shadow mask. The lower conical section of the envelope is sealed at its small end to a glass funnel-neck assembly.

The round tube shape was chosen in preference to a rectangular shape for greater stability of both envelope and internal parts, and for the lower cost of the simpler structure. The decision as to tube size was based on the popularity of 21-inch tubes for black-and-white television, which combine a picture size adequate for most homes with moderate deflection angle and over-all tube length. The use of metal rather than glass for the envelope contributes to ease of handling the tube, which is at least 10 pounds lighter than a comparable glass tube. In addition, the metal envelope provided more flexibility for design and development.

OPERATING PRINCIPLES

THE operating principles of the shadow-mask type of tricolor tube have been discussed fully elsewhere.[1] It should be mentioned, however, that proper parts dimensions and spacings, as well as accurate positioning of the mask with respect to the phosphor screen, are essential to satisfactory operation of such a tube.

PHOSPHOR-DOT SCREEN FABRICATION

ACCURATE deposition of the dots is accomplished by a photographic exposure process carried out in an apparatus called a "lighthouse." The lighthouse contains a light source and top cap holder so arranged that the source may be moved successively to three positions. These positions or "color centers" are to become the apparent electron sources in the deflection plane of the finished tube.

The procedure for fabrication of the phosphor dot screen consists essentially of the following steps: (1) coating the inner surface of the tube face with a uniform layer of one of the phosphors and a photoresist; (2) exposing the photoresist through the mask apertures and developing the array

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955, and recommended for publication by the AIEE Committee on Television and Aural Broadcasting Systems.

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The authors wish to give credit to their many colleagues and associates who helped to evolve this successful design.

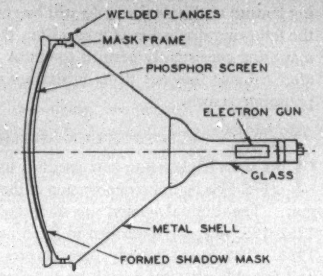


Fig. 2. Schematic diagram of 21-inch color kinescope

of dots thus exposed; (3) repeating these steps with each of the other two phosphors in turn; and (4) applying an aluminum backing to the screen surface.

The phosphors used are: for blue, a silver-activated zinc sulfide; for green, a manganese-activated zinc orthosilicate or willemite; and for red, an improved manganese-activated zinc phosphate.

Red emitting phosphors, in general, exhibit relatively lower efficiencies than the other two primaries, and thus limit the light output of any tricolor tube. An improvement in efficiency of the red phosphor, therefore, shows up directly in the brightness capabilities of the tube. In the *21AXP22*, this efficiency has been increased by about 30 per cent over that obtained in earlier color tubes.

The successive phosphor coatings are deposited on the faceplate by a new method which gives improved quality at a considerable saving in time over the older settling method. The new process consists of flowing a thin paste or slurry containing phosphor and photoresist over the faceplate surface in such a manner as to provide a uniform coating. For this operation, a machine (Fig. 3) is used which gives the top cap a rotating and tilting motion at suitable speeds and angles. The proper amount of slurry is poured onto the center of the face and motion of the machine spreads the mixture outward. Excess slurry is thrown to the edge, from which it is drained off. The total time required for the application of the entire screen by the slurry method is about $2^1/_4$ hours, as contrasted with $4^3/_4$ hours per screen by the settling method.

To aid in the exposure process, several recent improvements have been built into the lighthouse. They include alteration of mechanical features to increase accuracy and ease of use, and a complete redesign of the light assembly. The new assembly not only is more efficient, but also provides approximately uniform light distribution over the entire screen surface. The resulting printed dots are uniform in size. In tube operation this dot uniformity contributes importantly to equalization of the brightness of each color field and particularly to white uniformity in black-and-white reception.

MASK DESIGN AND FABRICATION

The mask material is a cupro-nickel alloy, 95 per cent copper, 0.008 inch thick, which is highly satisfactory for etching. Inasmuch as the aperture array is fabricated by a photoengraving process, the latter characteristic is very important. Approximately 357,000 apertures, 0.010 inch in diameter, are etched within the useful area of each mask. The mask is formed from the flat etched sheet to the proper curvature edged by a short cylindrical section. This border fits closely around the light C-section frame and is welded to it. Thus, the mask is supported by a light rigid platform which is sufficiently rugged to hold the mask in shape during its repeated insertions into the top cap.

MASK MOUNTING

Satisfactory mounting of the frame within the top cap has been the subject of considerable developmental effort. To appreciate the logic behind the present mounting design, one should bear in mind certain facts concerning tube construction and processing. In the first place, the mask, frame, and envelope are of different metals having different coefficients of expansion, and these assembled parts must be heated to about 400 C during the exhaust process. In the second place, any net displacement of

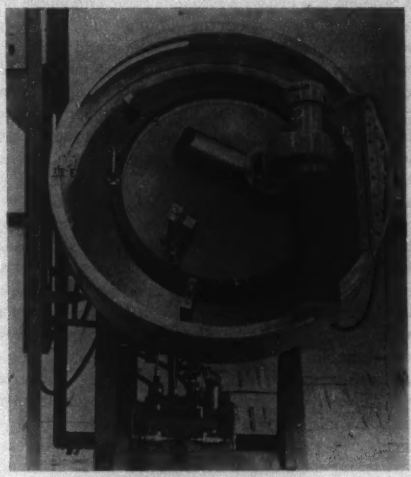


Fig. 3. Slurry equipment used for application of phosphors

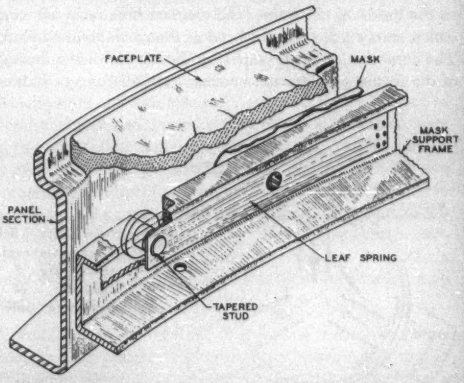


Fig. 4. Detail of spring mounting for shadow-mask support frame

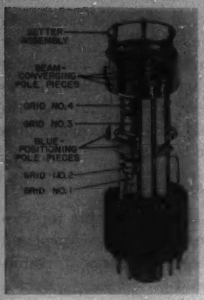


Fig. 5. Electron-gun assembly

mask apertures which results from this processing causes a shift of the electron beams from their proper landing positions on the phosphor screen, a condition of misregister which produces color dilution. From the beginning of color tube work at RCA, it was clearly understood that some means was required to permit differential expansion of parts during tube processing and simultaneously to prevent any permanent change in the shape and position of the parts.

In the shadow-mask tubes having flat masks and screens, this problem was met by a system of three pins whose heads fitted into radial grooves in the phosphor plate. The pins, mounted from the heavy mask frame, could slide in the grooves as required during heating and cooling. This system with its rigid frame automatically brought the mask back to its initial position upon return to room temperature.

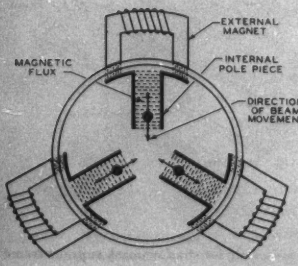
In the *21AXP22*, however, it was desired to avoid loss of any picture area which would be required by a mounting device on the faceplate surface. The frame supports were therefore attached to the metal rim of the top cap. A set of posts or studs, projection welded to the metal, proved to be a sturdy satisfactory form of support.

The next consideration was how best to mount the mask frame from these studs. Previous experience with a 3-point radial sliding mechanism suggested a modification of this method for the new construction. It was found, however, that friction between the metal parts, particularly after exhaust treatment, resulted in binding or, at best, erratic slipping of one part against another. A spring mounting method completely free of the vagaries of friction coefficients was then tried. Fig. 4 shows the highly satisfactory spring mounting used in the *21AXP22*. Because of the stability of the mask frame, three leaf springs have prove adequate for its support. These springs are fastened to the inside of the frame, each with a hole near one end which seats on the tapered head of the corresponding stud. The combination of the taper on the stud with the flexing of the spring provides the necessary self-aligning or indexing feature of this device. As will be covered more fully in the following discussion of misregister, the frictionless frame mounting consistently permits the mask assembly to return after exhaust bakeout to its initial position relative to the phosphor screen.

ELECTRON-GUN ASSEMBLY

The short triple-beam gun assembly used in the *21AXP22* (Fig. 5) is an improved version of the internal pole piece gun. The original version was undergoing development in 1952–1953 and was described to RCA licensees in January 1954. The gun assembly incorporates electrostatic focus and combined mechanical and magnetic convergence. The three electron guns, each including a heater, cathode, control grid, accelerating grid, focusing grid, and high-voltage grid, are inclined at a small angle to the axis of the assembly to converge the beams at the center of the mask. Cathodes, control grids, and accelerating grids are all electrically isolated to permit cathode and/or grid modulation and adjustment of drive characteristics to fit receiver requirements. The new gun assembly is so designed as to economize on neck length and at the same time produce a narrow high-current-density beam. The focusing grid structure has been designed in relation to the accelerator grid to form a small crossover at high voltage for sharp focus. The "prefocusing" action between these electrodes, together with the shortness of the focusing grid, provides a narrow beam in the focusing and deflection regions, a characteristic which has triple usefulness. A narrow beam leads to high gun efficiency, reduced aberration in the focusing lens, and improved screen tolerance in respect to color purity. This increased tolerance results from the fact that the diameter of the fluorescent dot in a shadow-mask tube is a function of the beam diameter in the deflection field. Thus, a narrow beam provides greater tolerance in landing position of the electrons with respect to the phosphor dot. The short gun has a further advantage in that alignment of its parts is less critical.

In addition to the mechanical convergence built into the gun, which superimposes the beams only at the center of the mask, dynamic convergence is needed in synchronism with the scanning to maintain convergence over the entire mask. The beam angle variations needed for this purpose are produced by a separate magnetic field acting on each beam. To form these fields three pairs of radial pole pieces, located at the top of the gun (Fig. 6), are excited by three



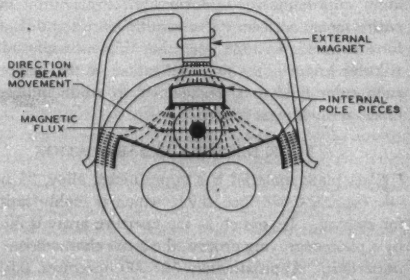


Fig. 6 (left). Schematic of beam-converging pole pieces. Fig. 7 (right). Schematic of blue-positioning pole pieces

external electromagnets. Thus an appropriate field variation may be applied to each beam individually as required by the geometry and electron optics of the system. Any inaccuracy of mechanical convergence may be corrected by application of d-c fields, as needed, to the three radial pairs of pole pieces and an additional tangential pair located further back on the "blue" gun (Fig. 7). These blue positioning pole pieces are shown in Fig. 5. The combined mechanical and magnetic convergence incorporated in this gun design offers a number of distinct advantages over earlier convergence methods. The maximum voltage brought through the base is that of the focusing electrode, nominally 4,500 volts. This low voltage, together with a new base design, eliminates serious leakage troubles. As the pole-piece structure and neck coating operate at the same potential, a number of getters may be placed at the top of the gun and flashed to produce a large active area. Mechanical convergence of the beams provides good stability of convergence regardless of voltage fluctuations. Finally, the application of a magnetic field to each of the three beams separately provides the flexibility needed to obtain accurate dynamic convergence over the entire picture area, even at the relatively wide deflection angle used. All of these factors add up to the production of a high-fidelity high-definition stable picture devoid of color fringing and color shading.

GEOMETRICAL CONSIDERATIONS

Without going into the mathematical details of the tube geometry, it may be stated that the design dimensions of the curved mask system are worked out so as to provide for uniform picture element size and optimum coverage of the phosphor screen area.

FACTORS AFFECTING REGISTER

The preceding geometrical considerations are basic in the design of the tube. However, regard must also be given to probable deviations from the assumed mechanical dimensions and operational characteristics. From the printing industry the term *register* has been borrowed to convey the idea of the accurate landing required of the electron beams on the appropriate phosphor dots. Perfect register, then, indicates that the center of each fluorescent spot coincides with the center of the corresponding phosphor dot. Naturally, the chief concern is with *mis*register which generally results in impure or even incorrect colors appearing in parts of the picture.

After the tube has been designed as indicated by the development of its geometry, and the screen photographically deposited according to this geometry, it is well to consider what factors can cause misregister in the picture produced by the completed tube. The causes are either mechanical or electrical. Mechanical effects will be considered first in the following:

Processing Deformations. The tube and its parts are subjected to various mechanical stresses between the time of screen application and the completion of the tube. The top cap must be baked in air, and then welded to the lower cone. The tube must then be exhausted and baked while under vacuum. Thus, the tube parts may suffer a deformation due to thermal effects and to mechanical stresses on the envelope, including atmospheric pressure. Extensive tests on the *21AXP22* have indicated that resulting deformations occur, but are rather small. They are composed almost entirely of a radial component of misregister with respect to the tube axis, due principally to a minute flattening of the faceplate from atmospheric pressure. In effect, the mask is mechanically isolated from its environment by the frictionless spring-type mounting, which permits one or more of the springs to absorb distortion of the envelope without transmitting this motion to the frame or to the mask.

Inaccuracies of Parts Assembly. Another potential source of mechanical misregister is misalignment between gun and screen. As already indicated, it is necessary for proper operation that the electron beams reaching the screen appear to originate at the color centers previously set by the light source during screen fabrication. This alignment is achieved by using a set of reference points repeatedly during tube manufacture. The reference points consist of three dimples approximately 120° apart stamped in the top cap flange. The dimples mate with three V-grooves in the lighthouse and thus position the top cap uniquely with respect to the light source. The flange of the lower cone is likewise stamped with a set of V-grooves, with reference to which the neck and gun seals may be made. Finally, after screen fabrication and mask insertion, the dimples and V-grooves in the flanges are mated to position the top cap uniquely with respect to the lower cone, and the final weld is made. This procedure of referencing parts positions always from the same set of three dimple-and-groove locations reduces misalignment between gun and screen to a small value. As will be indicated later, compensation may readily be applied for this small residual error.

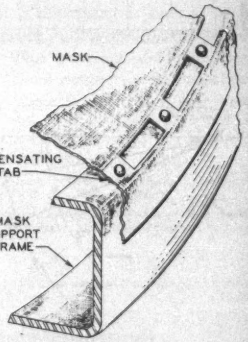


Fig. 8. Detail of shadow mask showing thermal compensating tabs

Mask Expansion. Motion of the mask apertures results from heating under electron bombardment. The mask's shadowing function, of course, requires that it intercept a large fraction of the total electron current—about 85 per

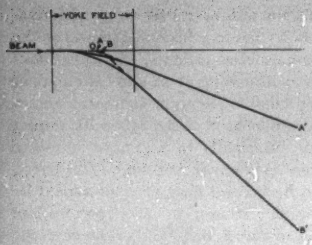


Fig. 9. Motion of deflection centers

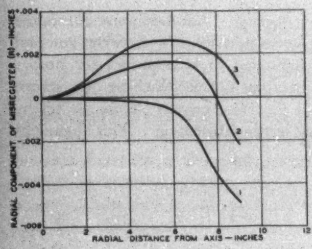


Fig. 10. Radial component of misregister as a function of distance from tube axis

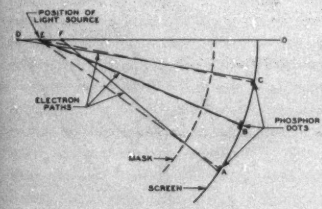


Fig. 11. Radial error with yoke in compromise position

cent. If heating effects are such as to move an aperture a short distance *along* the path of the beam which passes through it, the change cannot be noticed. However, if the aperture moves *transversely* to the beam path, the fluorescent spot moves about the same distance and misregister ensues.

Therefore, since mask heating and resultant expansion are unavoidable, the desirable condition is that the whole mask move a small distance toward the screen as it expands. If it were restrained at the edge, it would bow toward the screen and the apertures in a wide zone between center and edge would have an undesirable component of lateral motion. On the other hand, if it were unrestrained at the edge but fixed as to distance from the screen, the lateral aperture displacement would increase from zero at the center to a high value at the edge.

To prevent restraint at the edge and provide the desired motion toward the screen, a series of holes is punched around the border of the array (Fig. 8), leaving a set of tabs or hinges connecting the array and the frame. These hinges are formed at about 45° to the side of the frame so that the tangential thrust of the mask expanding with respect to the frame causes the hinges to rise away from the frame and lessen the distance from mask to screen.

The electrical factors in misregister may be of several sorts.

Yoke Effects. As has been known for many years, the effective center of deflection of a yoke moves toward the screen as the deflection angle is increased. This motion appears whether a modern deflecting yoke having a flared "front end" and extensive fringe fields, or a hypothetical simplified yoke having "flat" fields and no fringes, is considered. Its magnitude is a function of yoke length and beam deflection angle. Fig. 9 illustrates this point. Starting with a very small deflection angle, for which the apparent center of deflection is at the mid-plane of the yoke O, the deflection is increased to A'. The apparent deflection center for this ray is point A, while the center from which ray B' appears to come is point B. Now, because of this motion and the fact that the phosphor dots were exposed simultaneously from a stationary source of light, the electron paths are dissimilar from those of the light rays. The resulting error is radial with respect to the tube axis. Fig. 10 indicates measured values of this radial component of misregister as a function of distance from the tube axis. The ordinate R is the magnitude of the radial component, with R positive when the beam is displaced toward the tube axis from its proper landing position. Adjustment of yoke position shifts the error as indicated by curves *1*, *2*, and *3*. Thus the error may be compromised between different zones in the screen (curve *2*), with results as shown in Fig. 11. In this figure, the light rays which exposed the screen are indicated by dashed lines, emanating from a small source at E, while D, E, and F represent successive deflection centers as the electron beam is deflected to wider and wider angles during tube operation. The axis of the electron beam leaving deflection center E (in this case the original light source position) lands precisely on the center of phosphor dot B, while the wide-angle electron ray from F falls radially outside the center of dot A and the narrow-angle ray from D falls inside the center of dot C. To re-

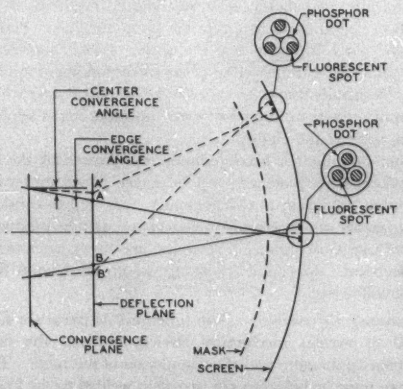


Fig. 12. Effect of dynamic convergence

move this error, precompensation may be built into the tube by suitable correction during tube fabrication. Thus the radial error due not only to the yoke, but also to the mechanical deformation mentioned previously, is eliminated.

Dynamic Convergence Effects. As mentioned previously, dynamic convergence involves variation of the relative angles of the three beams as they scan the screen in order to maintain convergence throughout the raster. Because the beam angles must be altered by a convergence means located in the gun some distance back of the yoke, the separation of the beams as they pass through the deflection plane changes simultaneously with the dynamic field. Fig. 12 illustrates the process by showing for simplicity two beams in the plane of the axis. As the screen is scanned out to its edge, the convergence angle of the beams must be decreased, thus moving their deflection centers from A to A' and from B to B'. Now, the triad of fluorescent spots produced by the three beams passing through an aperture is, in effect, a demagnified image of the three beams as cut by the deflection plane. Thus, when dynamic convergence fields are applied, the object in the deflection plane AB is enlarged to $A'B'$ and its image, the fluorescent triad, is correspondingly increased in size. The phosphor screen was exposed from light sources at A and B, and the undeflected beams pass through these color centers. When deflection and dynamic convergence fields are applied, the fluorescent spots are "degrouped" with respect to the phosphor dot triads. Several promising approaches for elimination of this error are being investigated. In the interim, of course, the error may be minimized by splitting it between center and edge of the screen.

Effect of the Earth's Field. Although the earth's magnetic field is of small magnitude and the electrons travel at high velocity, the influence of the field on the beam direction and landing may be appreciable in terms of misregister. If the force on the beams were uniform throughout the tube, the effect could be compensated by a fairly simple shift. In the neck region, where it is nearly uniform, a transverse field is generally applied over the gun by the "purifying magnet," which serves simultaneously to correct for any slight misalignment between gun and screen. However, in the cone region the effect of the earth's field on the beam varies with the angle of deflection, so that the resulting misregister is far from uniform over the screen area. Furthermore, this misregister pattern changes with the orientation of the tube in the earth's field. The metal envelope of the tube provides partial shielding and tends to redistribute the field. The resulting misregister is such as to be readily corrected by a magnetic field system placed around the front end of the tube. This "magnetic-field equalizer" (Fig. 13) consists of eight small magnets, with associated pole pieces, which are adjustable as to strength and direction.

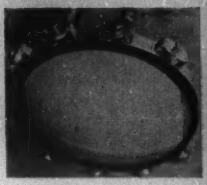


Fig. 13. Magnetic-field equalizer in position on the RCA 21AXP22

REFERENCES

1. A Three-Gun Shadow-Mask Color Kinescope, **H. B. Law.** *Proceedings*, Institute of Radio Engineers, New York, N. Y., vol. 39, October 1951, pp. 1186–94.

2. Development of the RCA 21-Inch Metal-Envelope Color Kinescope, **H. R. Seelen, H. C. Moodey, D. D. VanOrmer, A. M. Morrell.** *RCA Review*, Princeton, N. J., vol. 16, March 1955.

Analogue Computer Designed for Use by Aircraft Engineers

A new specialized analogue computer, designated the Aerolog performance computer, which will accurately calculate steady-state rates of climb, maximum speeds, lift coefficients, and climb angles of any airplane, has been developed by Link Aviation, Inc., Binghamton, N. Y.

The computer is unique in that it is especially suited for operation and use by aircraft design groups rather than requiring a group of specialists. All inputs are in a form familiar to the aeronautical engineer.

Output of the device is based on the following input variables: Mach number, pressure ratio, speed of sound ratio, engine thrust, airplane gross weight, reference area, and profile and induced drag coefficients. Under assumed steady-state conditions, the computer exactly solves the two longitudinal equations of motion simultaneously. Individual computations are made with accuracy consistent with input accuracy, or to 0.1 per cent of full scale.

The range of variables for Mach number is 0 to 4.0, for gross weight it is 0 to 1 million pounds, and for reference area it is 0 to 10,000 square feet. Pressure ratio is 1.10 to 0, and speed of sound ratio is 1.10 to 0.

Utilization of Aluminum Distribution Conductors

C. E. NELSON
MEMBER AIEE

K. S. GARRETT
ASSOCIATE MEMBER AIEE

MANY things have been done to check the spiralling transmission and distribution costs, such as use of higher voltages for transmission, rerating of existing equipment, and eliminating nonessentials. Possibilities were recognized in the use of aluminum prior to 1950, but plans for experimental installations were abandoned because of inability to clear up important design details.

The Korean war changed this situation. New residential housing and industrial and commercial building continued unabated, but copper conductors, especially bare or weatherproof types, were unavailable. Aluminum, being available, was adopted for general use in distribution.

The solution of design problems was given tremendous impetus as aluminum was known to have characteristics which would require special attention if it were to be used successfully. Investigation was made of the physical strength, electrical conductivity characteristics, susceptibility to atmospheric and galvanic corrosion, and of effects obtained during temperature cycling when aluminum was used with fittings of other metals. Utilizing information obtained, design work was initiated on a very conservative basis.

Investigation of higher load densities expected in the new housing developments showed that the established design principles of co-ordinating the conductor sizes with acceptable voltage drops required little change. On this basis, the primary mains became #4/0 steel-reinforced aluminum cable (ACSR); the ties between mains, #1/0 ACSR; and #4 ACSR was selected for branches. For secondaries, #4/0 all-aluminum was used with the common neutral being #1/0 ACSR bare. For residential services, #4 conductor was used in several constructions; larger conductor being employed for commercial and industrial loads.

Taps, terminations, and dead-end construction were given careful and detailed treatment. The principal problem was to provide a suitable connector for joining aluminum and copper. To minimize corrosion and conductor distortion and to provide permanent connections of adequate pressure, plated copper connectors of large contact areas were selected. An inhibiting grease and tape were applied to exclude moisture and air.

Copper jumpers were used in connections to transformers, arresters, and other devices.

Construction work was begun following these procedures and over 31-million conductor feet were installed between March 1, 1952, and December 1, 1954. No serious difficulties were encountered in the field, although several changes in original designs were found to be desirable. As one, the taping of greased tap connections on bare conductors was found to be of doubtful value, if not actually harmful, and this time-consuming procedure was eliminated.

In the fall of 1953 after approximately 18 months of satisfactory experience with aluminum conductors, designs were reviewed for possible simplifications and economies. Field tests indicated that bare aluminum conductors could be safely utilized in the standard rack construction, using 8-inch spacing, provided spacers were added at approximately 50-foot intervals. The addition of spacers permitted their use as a terminal point for services to customers. The net savings effected by thus using bare aluminum, as compared to covered aluminum, amounts to approximately 15 cents per circuit foot of 3-wire 115/230-volt secondary. In addition, service lengths are kept to a minimum since they can be installed substantially at right angles to the line in practically all instances.

The possibilities for similar economies in designs for primary voltages also were investigated. Reliability and strength considerations have weighted the decision in favor of steel reinforced conductors for all primaries, however, and improvements in installation techniques have represented the principal savings in primary construction.

In the matter of connectors, there has been a continuous investigation and screening of the host of available plated bronze and aluminum alloy designs. The present list of approved tap connectors and dead-end clamps represents numerous revisions and embraces split-bolt designs with bell-mouth washers, 2-bolt types in tin-plated copper and bronze, and parallel groove and "U"-bolt types employing aluminum alloys. Compression methods are standard for splicing.

Reviewing experience to date with aluminum in aerial distribution, some problems have evolved which require attention. Heading the list is a satisfactory solution to the connector problem. Also, a number of construction and maintenance factors have been troublesome. For example, work on energized ACSR circuits is more complicated and costly than with copper; and having both copper and aluminum plant requires stocks of both to be maintained in storerooms and on trucks. In addition, lack of suitable terminals on line devices creates joining problems.

Aluminum has given satisfactory performance in carrying load, and there has been a reduction in construction costs.

General equipping of line devices, transformers, cutouts, etc. with terminals suitable for both aluminum and copper would be of substantial benefit.

Continuance of industry-sponsored research into the problems affecting aluminum connector design should contribute greatly to the fuller realization of economies and conveniences that are potential in the use of aluminum in distribution.

Digest of paper 55-249, "Design Problems and Operating Experience with Aluminum Distribution Conductors in the Philadelphia Electric Company," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Electrical Utilization of Aluminum Conference, Pittsburgh, Pa., March 15–17, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

C. E. Nelson and K. S. Garrett are with the Philadelphia Electric Company, Philadelphia, Pa.

INSTITUTE ACTIVITIES

View of The Sunshine Skyway, St. Petersburg, Fla.

Southern District Meeting to Include Many Social Activities, Technical Sessions

The AIEE Southern District Meeting will be held in St. Petersburg, Fla. April 13–15, 1955. The Soreno Hotel will serve as headquarters for the meeting and all technical sessions will be held there.

A well-rounded technical program will be presented, which will include public relations, power plant, power equipment, transmission lines, telephone, radio, television, atomic energy, phosphate mining, citrus canning, paper and pulp, semiconductors, and magnetic amplifiers.

SOCIAL ACTIVITIES

Social activities for members and guests are complete in every respect. There will be a hospitality hour, two general luncheons, a cocktail party, and dinner dance. For the ladies there will be informal teas and social hours, and a variety of sightseeing trips.

Dr. Theodore H. Blau, of Byron Harless and Associates, Inc., will be speaker at the Wednesday luncheon. Mr. C. J. Hendon, vice-president, General Electric Company, and Col. J. Norman Pease, president, H. N. Pease Company, will speak at the Thursday luncheon.

Early arrivals will be entertained at an informal hospitality hour between 5:30 p.m. and 6:30 p.m. on Tuesday evening, April 12. This social period will be held on the mezzanine of the Soreno Hotel. Members and their families and guests will be able to renew old friendships and acquaintances. Tea, coffee, and cocktails will be served, and members of the District 4 Executive Committee will be honored guests.

GENERAL SESSION

This meeting will be called to order at 9:30 a.m. on Wednesday, April 13, by Mr. I. L. Garcia, chairman. Mr. Garcia will introduce Mayor Samuel G. Johnson of St. Petersburg, who will deliver a welcome message. Next, Mr. Charles P. Almon, Jr., vice-president of District 4, will take charge of the General Session, and will introduce President Monteith. Mr. Monteith will speak on Institute affairs. William J. Clapp, president of the Florida Power Corporation, will then introduce Dr. J. Ollie Edmunds, president of Stetson University, who will deliver the main address. Dr. Edmunds subject will be, "The Human Side of Business."

LADIES PROGRAM

The ladies' headquarters will be in the Terrace Room of the Soreno Hotel. Coffee will be served each morning, and hostesses will be on hand at all times to extend a welcome, and to answer any questions.

A tour of Cypress Gardens will take place Wednesday, April 13. Rare and exotic plants are gathered from various parts of the world in the gardens. Luncheon on the Palm Terrace will be highlighted by a water ski show by the Aquamaids. Later, electric boats will take passengers through lagoons.

On Thursday, April 14, a tour will be made of Weekiwachee Springs, where the Mermaids Ballet will be seen from the Underwater Theatre. Here it is possible to look down more than 100 feet into one of the deepest clearest springs in the world to see marine life. Luncheon will be in the Patio Restaurant. Also, the Congo Belle, a paddle-wheel boat, will provide transportation along the Weekiwachee River where rare and familiar animals can be seen.

Informal socials will be provided Tuesday and Thursday evenings. The ladies will join the gentlemen on Thursday evening for a banquet and dance. Arrangements for golfing and deep-sea fishing parties will be made upon request.

ADVANCE REGISTRATION

Advance registration is encouraged. Total cost for all activities (package plan): members $20.00, nonmembers $25.00, ladies $20.00. Members' registration fee of $2.00 and nonmember-registration fee of $3.00 is included in these prices. The "package plan" cost is one-third less than the cost of individual tickets to various activities. Registration facilities will be located in the lobby of the Soreno Hotel.

HOTEL RESERVATIONS

A large number of rooms are available at the Soreno Hotel, convention headquarters, and other nearby hotels. All requests for reservations should be sent to the Soreno Hotel, First Avenue and Beach Drive North, St. Petersburg, Fla. Reservation requests should be made prior to April 1 and AIEE should be mentioned.

Reservation requests will be accommodated in the Soreno Hotel (meeting headquarters) where possible, with the overflow being assigned to nearby hotels at current prices. Accommodations at the Soreno Hotel are as follows:

Single Room with Bath	$6.00	European,	$11.00	American
Double Room	9.00	"	20.00	"
Twin Bed Suite with Parlor			30.00	"

STUDENT ACTIVITY

The Student Council for District 4 will hold a student meeting with 200 expected attendance from universities and colleges throughout the southern area. This meeting will be held at St. Petersburg simultaneously with the District meeting. Plans include financial help toward cost of the student program. There will be a subcommittee

HIGGINS Steam Generating Plant of the Florida Power Corporation, is one of the inspection trips scheduled for the Southern District Meeting

composed of three members: Chairman Professor C. R. Vail, counselor, Duke University; Professor F. T. Tinsley, Clemson Agricultural and Mechanical College; and Professor E. R. Weston, Georgia Institute of Technology. They will be judges for the student paper awards to be presented at the banquet.

TRANSPORTATION

Access to St. Petersburg can be made by rail, air, or highways. The Atlantic Coast Line and the Seaboard Air Line have regularly scheduled connections to St. Petersburg. The Eastern Air Lines and National Air Lines also have good schedules into the city. The best highway connections from the North are U. S. Routes 19 and 41.

COMMITTEE

Members of the 1955 Southern District Meeting Committee are: General Committee: I. L. Garcia, general chairman; J. D. Hicks, vice-chairman; N. Patterson, secretary; Don Knauss, treasurer; Advisory Committee: W. J. Clapp, M. R. McKinley, James G. Spencer, Jr., J. Arthur Turner, Sr., and C. J. Ellis; Ladies' Program: Mrs. Amy Thompson, chairman; Members at Large: C. P. Almon, Jr., Vice-President, District 4, and T. H. Mawson, secretary, District 4; Finance: G. L. Kenny, Jr., chairman; Technical Program: Ben Darlington, chairman; Turner Loehr, vice-chairman; Publicity: Milton O. Hollis, chairman; Student Activities: Perry Gibbons, chairman; Paul H. Nelson, vice-chairman; Hotel Arrangements: W. V. Bracken, chairman; Registration: T. F. Thompson, Jr., chairman; Banquet and Social: R. E. Raymond, chairman; Trips and Transportation: J. H. Rose, chairman; Printing and Tickets: B. R. Gaffner, chairman.

Tentative Technical Program

Southern District Meeting, St. Petersburg, Fla.

Wednesday, April 13

9:30 a.m. General Session

Introduction: I. L. Garcia, general chairman

Welcome Address: Mayor Samuel G. Johnson, St. Petersburg, Fla.

Address: President A. C. Monteith.

The Human Side of Business. *Dr. J. Ollie Edmunds.*

2:00 p.m. Public Relations

DP. Human Engineering—A New Frontier.** *T. M. Ware*, International Minerals and Chemical Corporation

DP. The Social Aspects of Business.** *Frank Laver*, Peninsular Telephone Company

DP. Shocks from Southern Industry.** *B. R. Askew*, professional engineer

2:00 p.m. Power Handling and Plant Operation and Equipment

DP. Continuous Demand Metering.** *R. J. Owens*, Tennessee Valley Authority

55-11. Behavior of High Voltage Busses and Insulators During Short Circuits. *R. M. Milton* and *Fred Chambers*, Tennessee Valley Authority

DP55-552. Importance of Actual Experience in the Operation and Maintenance of Power Plants. *R. B. Lee*, Florida Power Corporation

55-353. Increased Current Ratings for Step Regulators. *W. C. Sealey*, Allis-Chalmers Manufacturing Company

2:00 p.m. Semiconductors

DP. An Experimental Automobile Receiver Employing Transistors.** *L. O. Freedman, T. O. Stanley* and *D. D. Holmes*, Radio Corporation of America Laboratories

DP. Ferrites—New Materials for Electronics.** *P. N. Russell*, General Electric Company

DP. Recent Developments in Silicon Diodes and Transistors.** *Jay Thornhill*, Texas Instrument Company

DP. Direct Conversion of Radiation to Electrical Energy.** *E. G. Lender, P. Rappaport, J. J. Loferski*, Radio Corporation of America Laboratories

2:00 p.m. Magnetic Amplifiers

DP. Introduction to Magnetic Amplifiers—Part I.** *Clarence Shutzenbecker*, Western Electric Company

DP. Introduction to Magnetic Amplifiers—Part II.** *H. E. Whitted, Jr.*, Western Electric Company

DP. Introduction to Feedback Control Systems.** *A. R. Eckels*, North Carolina State College

DP. Magnetic Amplifier Instrument Servomechanism.** *J. F. Koenig*, Duke University

2:00 p.m. Special Session—Poles and Aluminum Connectors

DP. Steel Poles.** *L. F. Heckmann* and *J. O. Hammond*, Union Metal Manufacturing Company

DP. Aluminum Poles.** *J. O. Hammond* and *L. F. Heckmann*, Union Metal Manufacturing Company

DP. Concrete Poles.** *J. W. Lewis*, American Concrete Corporation

DP. New Developments in Connectors for Aluminum.** *Richard Harap*, Burndy Engineering Company

Thursday, April 14

9:00 a.m. Paper and Pulp Industry

DP. Integrating Amplifier Broaden Field for Application of Electric Drives.** *C. D. Buck*, General Electric Company

DP. Foxboro Magnetic Flow Meter as Applied to the Pulp and Paper Industry.** *C. A. Moher*, The Foxboro Company

DP. The Use of Magnetic Amplifiers in the Paper Industry.** *S. J. Campbell*, Westinghouse Electric Corporation

DP. A Comparison of Variable Speed Drives of Small and Medium Horsepower and Their Application in the Paper Industry.** *W. H. Buford*, Southern Advance Bag and Paper Company and *G. E. Shoad*, General Electric Company

DP. The Gas Turbine in Southeastern Pulp and Paper Mills.** *F. Wierk* and *W. L. Garlington*, Reynolds, Smith and Hills

9:00 a.m. Telemetering and Recording

DP. High Capacity PTM-AM Telemeter.** *G. F. Anderson*, Radiation Inc.

DP. Range and Coverage Characteristics of a High Capacity PTM-AM Telemetering System.** *J. E. Spooner*, Radiation Inc.

DP. 18 Channel PAM-FM Telemeter for VHF Bands.** *R. P. Bishop* and *George Shaw*, Radiation Inc.

DP. A High Speed, High Capacity, Direct Writing Recorder System.** *C. E. Keith*, Radiation Inc.

DP. Application Engineering for the Electro Stylus Recorder.** *Jack Petersen*, Radiation Inc.

9:00 a.m. Power Transmission Lines

DP. Insulation Characteristics of Wood and Porcelain in Series.** *J. M. Clayton* and *D. F. Shankle*, Westinghouse Electric Corporation

DP. Steel Tower Transmission Line Design and Construction.** *C. B. Benham*, Florida Power Corporation

DP. Practices and Results of Transmission Line Lightning Protection in Florida.** *I. L. Garcia*, Florida Power Corporation

DP55-554. Protective Relay Modernization Program Releases Latent Transmission Capacity. *M. F. Hebb, Jr.*, Florida Power Corporation and *J. T. Logan*, engineering specialist

9:00 a.m. Communication—Carrier and Radio

DP. Communication Development in Florida.** *J. W. Travis*, Southern Bell Telephone Company

DP. Type 45—Universal Carrier Equipment.** *R. R. Sanders*, International Automatic Electric Company

DP. Outside Plant Considerations with High Frequency Carrier Systems.** *J. N. Petris*, Automatic Electric Sales Corporation

DP. Solving Noise and Crosstalk Problems with Compandors.** *T. B. Collins*, Automatic Electric Sale Corporation

9:00 a.m. Phosphate Mining and High Voltage Cable

DP. Electrical Maintenance—Phosphate Mining and Flotation.** *J. L. Cox*, International Minerals and Chemical Corporation

DP. Instrumentation in the Phosphate Chemical Plant.** *E. L. Barker*, International Minerals and Chemical Corporation

DP. Grounding System Practices in Florida Phosphate Industry.** *W. Barbarowicz*, International Minerals and Chemical Corporation

DP. Performance Characteristics of High-Voltage Rubber-Insulated Cables.** *S. J. Rosch*, Anaconda Wire and Cable Company

2:00 p.m. Telephone Switching and Basic Science

DP. The Problems and Methods of Automatically Computing Toll Calls.** *J. D. Confeld*, Stromberg Carlson Company

DP. The Tampa Area Intertoll Switching System.** *R. W. Jones*, Stromberg Carlson Company

DP55-355. The Application of the Theorem of Superposition for the Generalization of the Theorems of Thevenin and Norton. *W. J. McKune* and *D. L. Finn*, Georgia Institute of Technology

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33 West 39th Street,
New York 18, N. Y.

2:00 p.m. Atomic Energy

DP. Control of High-Voltage Equipment Use in the Acceleration of Positive Nuclear Particles.** *H. E. Banta* and *R. F. King*, Oak Ridge National Laboratory

DP. The Savannah River Plant of the Atomic Energy Commission.** *Winston Davis*, Atomic Energy Commission

DP. A Package Power Reactor for Remote Locations.** *A. L. Boch*, Oak Ridge National Laboratory

DP. The Homogeneous Reactor as a Central Station Power Plant.** *R. B. Briggs*, Oak Ridge National Laboratory

2:00 p.m. Aircraft Testing Power

DP. The Arnold Engineering Development Center Power System.** *D. J. Goodman*, ARO, Inc.

DP. Unusual Relaying and Control Problems at the Arnold Engineering Development Center.** *J. J. Komisky*, ARO, Inc.

DP. Electric Equipment in the Arnold Engineering Development Center Test Facilities.** *R. C. Carter, Jr.*, USAF, A.E.D.C.

2:00 p.m. Lightning Arresters and Cathodic Protection

DP. Some Lightning Arrester Application Factors.** *J. E. Barkle* and *T. J. Bliss*, Westinghouse Electric Corporation

DP. The New Thyrite Magne-Valve Line-Type Arrester.** *W. H. Eason, J. H. Snell* and *A. A. Olsen*, General Electric Company

DP. Relay and Fuse Protection of Tapped Transmission Lines.** *C. W. Cogburn*, Florida Power and Light Company

DP. Cathodic Protection in Power Plants.** *J. B. Prime, Jr.*, Florida Power and Light Company

2:00 p.m. Radio

DP. VHF Communications System Requirements Today and Tomorrow.** *R. L. Cassulberry*, General Electric Company

DP. The Effect of Atmospheric Noise on a Frequency-Shift Radioteletype System.** *S. P. Herzperger*, University of Florida

DP. Solar Flares and Atmospheric Noise.** *E. I. King*, University of Florida

2:00 p.m. Television–Microwave

DP. Color Television—Its Progress, Its Problems, Its Promise.** *L. R. Fink*, General Electric Company

DP. Microwave as a Medium for Electrical Utility Relaying.** *N. B. Tharp*, Westinghouse Electric Corporation

DP. On Television and Aural Broadcasting.** *C. M. Braun*

Friday, April 15

9:00 a.m. Atomic Energy and Instrumentation

DP. Objectives, Utilization, and Instrumentation of the Raleigh Research Reactor.** *H. A. Lamonds*, North Carolina State College

DP. Recent Developments in Nuclear Instrumentation.** *F. M. Glass*, Carbide and Carbon Chemicals Company

DP. Future Prospects for the Atomic Energy Industry.** *J. A. Swartout*, Oak Ridge National Laboratory

9:00 a.m. Transformers and Capacitors

55-356. Intermittently Increased Kilovar Output of Large Capacitor Banks. *P. M. Mindel*, Line Material Company

DP. A New Industry in the South; General Electric Transformer Plant in Rome, Ga.** *R. A. Nelson*, General Electric Company

DP. Use of Series Capacitors with Distribution Transformers.** *N. M. Neagle*, General Electric Company

DP. Reduced Insulation; Key to Sound Transformer Economy.** *O. T. Kirby, J. R. Meador*, Florida Power and Light Company

9:00 a.m. Citrus Processing and Container Manufacturing

DP. Florida Citrus Industry.** *Ansley Watson*, Pasco Packing Company

DP. Citrus Processing.** *King Kenrick*, Pasco Packing Company

DP. Electric Power in Citrus Processing.** *Don Wiggins*, Pasco Packing Company

DP. Can Manufacturing in Florida.** *F. W. Gaylord*, American Can Company

9:00 a.m. Computers—Motors—Cable

DP. The Application of Computers for Power System Operation.** *C. Nichols*, Leeds and Northrup Company

DP. Single-Phase Line Operation of Three-Phase Motors.** *H. T. Smith*, University of Louisville

DP. Modern Cable Insulations for Communication and Power.** *P. H. Ware*, Simplex Wire and Cable Company

Future AIEE Meetings

Rubber and Plastics Conference
Mayflower Hotel, Akron, Ohio
April 4–5, 1955
(*Final date for submitting papers—closed*)

Southern District Meeting
Soreno Hotel, St. Petersburg, Fla.
April 13–15, 1955
(*Closing dates for TP*—closed, DP**—closed*)

Middle Eastern District Meeting
Deshler-Hilton Hotel, Columbus, Ohio
May 4–6, 1955
(*Closing dates for TP—closed, DP—closed*)

Electric Heating Conference
LaSalle Hotel, Chicago, Ill.
May 10–11, 1955
(*Final date for submitting papers—closed*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 18–20, 1955
(*Final date for submitting papers—closed*)

Domestic Appliance Conference
Hotel Hollenden, Cleveland, Ohio
May 23–25, 1955
(*Final date for submitting papers—closed*)

Electronic Components Conference
Ambassador Hotel, Los Angeles, Calif.
May 26–27, 1955
(*Final date for submitting papers—closed*)

AIEE-APS-AIME-CIT Conference on Magnetism and Magnetic Materials
William Penn Hotel, Pittsburgh, Pa.
June 14–16, 1955
(*Final date for submitting papers—closed*)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(*Closing dates for TP—closed, CP***—Apr. 27*)

Pacific General Meeting
Butte, Montana
August 15–19, 1955
(*Closing dates for TP—May 16, CP—June 15*)

Petroleum Technical Conference
Shamrock Hotel, Houston, Texas
September 12–14, 1955
(*Final date for submitting papers—June 13*)

AIEE-ISA Instrument Conference
Shrine Auditorium, Los Angeles, Calif.
Sept. 12–16, 1955
(*Final date for submitting papers—June 13*)

AIEE-IRE Industrial Electronics Conference
Rackham Memorial Auditorium, Detroit, Mich. Sept. 28–29, 1955
(*Final date for submitting papers—June 28*)

1955 Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 3–7, 1955
(*Closing dates for TP—June 6, CP—Aug. 3*)

*TP—transactions papers
**TP—district papers
***CP—conference papers

Aerial view, Columbus, Ohio, scene of Meeting

AIEE Middle Eastern District Meeting Set for May 4–6 in Columbus, Ohio

The 1955 AIEE Middle Eastern District Meeting will be held May 4–6, 1955, at the Deshler-Hilton Hotel in Columbus, Ohio. An outstanding technical program has been arranged, and a social program that includes luncheons, a smorgasbord, and dinner-dance. Novel inspection trips are expected to heighten interest in technical sessions. Friday, May 6, will also be Student Meeting Day, when the district prize paper contest will be held.

TECHNICAL SESSIONS

There have been 22 technical sessions scheduled after the General Session. Different aspects of rotating machinery will be considered in four sessions, and three will be devoted to electric power systems. The Institute's General Committees will be represented in two sessions: one on management and the other on ethics.

Several sessions having an electronics slant will have papers on computers, semiconductors and solid-state devices, and aids to medicine. Two sessions each covering atomic power and communications systems are also scheduled and on the last day of the meeting, two sessions will be devoted to aircraft electric systems.

OPENING GENERAL SESSION

Philip Sporn, president, American Gas and Electric Service Corporation, will deliver the principal address at the Opening General Session, Wednesday, May 4, at 10:00 a.m. in the hotel ballroom. His topic will be: "Problems and Opportunities in Electric Utility Engineering." Mayor M. E. Sensenbrenner of Columbus will welcome the membership, and W. B. Morton, Vice-President, District 2, will open the session. AIEE President A. C. Monteith will also address members.

SMORGASBORD

A buffet dinner with entertainment will take place Wednesday Evening, May 4, 7:30–10:30 p.m. in the ballroom. The informal entertainment will be provided by the Earl March Trio and the Harmonaires. A seating plan will enable friends to sit at the same table. Tickets, costing $4.75 each, will be available at the registration desk.

DINNER-DANCE

The outstanding social event, a dinner-dance, will be held Thursday, May 5, 7:30–12:00 p.m. Dinner hour will be 7:30–9:00 p.m., and dancing from 9 o'clock to midnight. Chuck Selby and his orchestra will furnish the music. Price of tickets will be $5.75 each, also available at the registration desk. No advanced remittances should be sent for either the smorgasbord or the dinner-dance.

LUNCHEONS

Luncheons will be held at 12:30 p.m. in the ballroom of the hotel. The Wednesday, May 4 and Thursday, May 5, luncheons will be $3.00 each; ladies also invited. The Friday, May 6, luncheon will be a joint student luncheon, price $2.00. Student members will be admitted free. Cost for nonmember students will be $1.00. The Friday speaker will be President A. C. Monteith.

LADIES EVENTS

Ladies who attend as guests will have a varied and interesting schedule. A daily morning "coffee hour" will be held Wednesday, Thursday, and Friday, from 8:30–10:00 a.m., without charge. On Wednesday afternoon, the ladies will join Mrs. Lausche, wife of Governor Frank J. Lausche, for tea at the Governor's Mansion. Tickets for this will cost $1.00 each. On Thursday morning, a tour of the F. and R. Lazarus Department Store, one of the country's finest, is scheduled without charge.

One of the highlights for the ladies will be Thursday afternoon. A bus tour of the Ohio State University Campus and of some of Columbus' more scenic views will precede luncheon at Ilonka's Provincial House at 3:00 p.m. Tickets will be $3.00 each. Friday will be free for shopping or informal tours for which private transportation will be provided.

HOTEL RESERVATIONS

Rooms have been arranged for all members and guests at the Deshler-Hilton, headquarters hotel. Post cards should be mailed directly to the hotel. Reservations are suggested prior to April 18, with arrival on Tuesday afternoon or evening, May 3, the preferred plan. No reservations should be sent to the Hotel Subcommittee. Prices are as follows:

Deshler-Hilton Hotel (meeting headquarters), Broad and High Streets

Single	$5.50 to $ 9.00
Double	$9.50 to 13.50
Twin Bed	$10.00 to 14.50
Suites, Single or Double	$12.00 to 32.00

Rates at other Columbus Hotels are comparable.

REGISTRATION

Registration facilities will be open Tuesday, May 3, 6:00–9:00 p.m., Wednesday and Thursday, May 4 and 5, 8:00 a.m.–5:00 p.m., and Friday, May 6, 8:00 a.m. to noon.

Advance registration is encouraged by sending a card to the Registration Committee. This will enable the Committee to prepare programs and tickets, etc., in advance and facilitate the registration procedure in general. Do not enclose remittances with advance registration cards, as all fees will be collected upon arrival at the registration desks.

INSPECTION TRIPS

Five interesting inspection tours have been arranged, which should offer something to all members. Tickets should be purchased promptly upon arrival at the registration desk, as accommodations are limited. Bus transportation will be furnished for all tours.

Westinghouse Electric Corporation (Wednesday, May 4, 1:30 p.m.). This huge plant houses the Westinghouse Refrigerator and Freezer Division. Completed in 1953, this facility now produces approximately 2,400 units per day. It is one of the country's largest buildings, and is an outstanding example of overhead conveyor and automatic welding techniques.

American Gas and Electric Corporation System Loading Computer (Thursday, May 5, 9:00 a.m.). The American Gas and Electric System Coordination Office, at 1384 Grandview Avenue, Columbus, houses this unique device. The computer is designed to determine instantaneously the correction factors to be applied in scheduling power-plant electric generation to minimize adverse effect of transmission losses on the system. This includes six operating companies in

Ohio, Indiana, Michigan, Kentucky, West Virginia, Virginia, and Tennessee.

Radio Telescope, Ohio State University (Thursday, May 5, 10:00 a.m.). This installation is located on the Ohio State University Farms, north of Lane Avenue and west of Kenny Road. It is one of the world's largest—160 feet long with 96 corkscrew-shaped antennas. Earlier this year, work of mapping the northern sky with this telescope was named 1 of the 10 most outstanding astronomical accomplishments of 1954. This project also helped locate the exact center of the galaxy or "Milky Way" in which our solar system is located.

North American Aviation Company (Thursday, May 5, 1:15 p.m.). One of America's oldest and largest airplane manufacturers operates this large Navy-owned plant. The *F-86* Sabre Jet and the *F-100* Super Sabre are produced here for the U.S. Air Force and Navy. Almost 15,000 employees from the Central Ohio area work at this factory, which is adjacent to Port Columbus, the Columbus Municipal Airport, and the U.S. Naval Air Station. Tickets for this trip must be purchased by noon, Wednesday, May 4, so names may be submitted for security clearance.

Battelle Memorial Institute (Friday, May 6, 9:00 a.m.). Located on a 50-acre tract, the buildings of Battelle, with more than 3/4 million square feet of laboratory floor space, houses more than 2,100 people engaged in contract industrial research on a nonprofit basis. Battelle also has a 400-acre site on the outskirts of Columbus. Facilities for pilot-plant and large-scale research are being developed there, as well as an atomic-energy research center. Other Battelle laboratories are located in Frankfurt, Germany and Geneva, Switzerland.

STUDENT ACTIVITIES

Friday, May 6, will be Student's Day, with the District Prize Paper Contest being held from 9:00 to 11:00 a.m., with an additional session from 2:00 to 4:00 p.m., if required. Students will lunch with members at 12:30 p.m. A student banquet will be held at 6:00 p.m. at the Ohio Student Union Building on the Ohio State University campus. Prizes, including the District first prize of $25.00, will be awarded at that time. After the banquet, open house will be held in the electrical engineering department at the University.

GENERAL COMMITTEE

Members of the 1955 Middle Eastern District Meeting General Committee are: E. K. McCoy, general chairman; G. M. L. Sommerman, honorary general chairman; R. C. McMaster, advisory; L. M. Moore, administration; G. R. Tamplin, co-ordinating secretary; N. J. Greene, budget and finance; D. E. Stafford, treasurer; E. E. Dreese, technical program; N. A. Smith, student meeting; C. K. Bishop, special meetings; P. L. Gilmore, Jr., entertainment; J. W. Cade, arrangements; E. O. Wolden, publicity.

Tentative Technical Program
Middle Eastern District Meeting

Wednesday, May 4

2:00 p.m. Ethics

DP55-265 Ethics—Paramount Professional Earmark. *C. J. Freund*, University of Detroit

DP Ethics and Engineering Organizations. *E. W. Seeger*, Cutler-Hammer Company

DP55-292 Developing a Professional Consciousness. *Cornelius Wandemacher*, University of Cincinnati

2:00 p.m. Atomic Power I

DP Research Tools for the Development of Atomic Power. *S. L. Fawcett*, Battelle Memorial Institute

DP55-266 An Industrial Approach to Atomic Power. *J. L. Everett*, Philadelphia Electric Company

DP The Present State of Power Reactor Development. *W. K. Davis*, U.S. Atomic Energy Commision

2:00 p.m. Electronic Aids to Medicine I

DP Color Television, An Aid in Medical Instruction. *F. M. Deerhake*, General Electric Company

DP A New Development in Retinal Photography. *J. H. Prince, John Cowan*, and *N. A. Smith*, Ohio State University

DP Xeroradiography, X-Ray Inspection by Xerography. *Harold Clark*, Haloid Company

DP55-267 Cinefluorography with a Screen Intensifier. *D. H. Steinweg*, Westinghouse Electric Corporation

2:00 p.m. Communications Systems I

DP Telefax Patron Switching. *W. B. Lloyd*, Western Union Telegraph Company

DP Rigorous Determination of the Capacitance and Characteristic Impedance of UHF Coaxial Rectangular Transmission Lines. *T. J. Higgins* and *J. Skilas*, University of Wisconsin

DP55-300 Railway Signaling—A Railway Signal System Employs Fail—Safe and Conventional Transmission Circuits and Equipment. *G. W. Baughman*, Union Switch and Signal Company

DP Solutions to Unreliability in Complex Electronic Equipment. *G. H. Shorr*, Wright Field Air Development Center

Thursday, May 5

9:30 a.m. Management

DP55-302 Planning, Control, and Appraisal of Performance in the Management of an Engineering Organization. *C. J. Bellar*, Cleveland Electric Illuminating Company

DP55-268 Human Engineering—The Key to Executive Growth and Development. *M. J. Evans*, M. J. Evans Company

DP The Plus and Minus of Supervision. *Paul Brouwer*, Rohrer, Hibler, and Replogle, consulting psychologists

9:30 a.m. Atomic Power II

DP Nuclear Power Reactor Control. *J. J. Stone*, Battelle Memorial Institute

DP Opportunities for Education in Nuclear Engineering. *C. E. Dryden* and *G. B. Carson*, Ohio State University

DP55-269 Atomic Energy from Electric Energy. *G. E. Jackson*, Goodyear Atomic Corporation

9:30 a.m. Electronic Aids to Medicine II

DP A Probe-Type Radiation Counter for Beta Particles. *D. T. Williams*, Battelle Memorial Institute

DP Probe Amplifiers for Nuclear Measurements. *E. Fairstein*, Oak Ridge National Laboratories

DP Medical Spectrometer. *J. E. Francis* and *P. R. Bell*, Oak Ridge National Laboratories

DP Gamma-Ray Projection Analysis. *W. G. Myers*, Ohio State University

9:30 a.m. Rotating Machinery I

55-270 Effect of Skew on Induction-Motor Magnetic Fields. *C. E. Linkous*, General Electric Company

55-271 Computation of Skin-Effects in Bars of Squirrel-Cage Rotors. *Michael Liwschitz-Garik*, National Electric Coil Company

DP55-272 Effect of Saturation on Air-Gap Flux Distribution. *N. F. Tsang*, University of Arkansas

DP Calculations of AC/DC Resistance Ratios for Stator Conductors. *D. S. Babb* and *J. E. Williams*, University of Illinois

55-273 Weighted Mutual Reactances for a Triple-Cage Motor Circuit. *E. R. Martin*, University of Michigan

9:30 a.m. Communications Systems II

DP55-289 Telephone Carrier for Subscriber Service. *R. E. Pickett*, North Electric Manufacturing Company

DP A Grass-Roots Telephone Man Looks at Research and Manufacturing. *G. W. Searle*, Wisconsin Telephone Company

DP 55-290 Color Video Transmission Over Intercity Television Networks. *G. J. Harms*, American Telephone and Telegraph Company

DP55-274 Nonmultiple Magnetic Frequency Changers. *H. M. Hugg*, Lorain Products Corporation

2:00 p.m. Rotating Machinery II

DP Ventilation of Enclosed Motors. *W. H. Mathews*, Westinghouse Electric Corporation

55-275 Some Factors Influencing the Temperature Rise of Armature Windings. *Michael Liwschitz-Garik*, National Electric Coil Company

DP55-276 Two-Axis Method of Analyzing Electric Machines. *K. Y. Tang* and *Robert Cosgriff*, Ohio State University

DP55-288 Low-Inertia Motors. *F. A. Yates*, Diehl Manufacturing Company

DP The Magnetostrictive Transducer as a Reciprocating Electric Motor. *B. A. Wise*, Battelle Memorial Institute

2:00 p.m. Electric Power Systems I

DP55-277 Developments in Substation Design. *F. W. A. Myers*, Philadelphia Electric Company

55-278 Basic Sequence Networks. *H. S. Kirschbaum*, Ohio State University

DP Insulation Application of Modern Power Transformers. *G. W. Clothier*, Allis-Chalmers Manufacturing Company

55-279 Interpretation and Significance of Tests Indicating the Concentration of Polar Compounds in Transformer Oil. *R. W. Johnson*, Line Material Company

DP55-280 New Method for Representing Zero-Sequence and Mutual Impedances for Faults on Overhead Lines. *A. L. Miller*, Cleveland Electric Illuminating Company

2:00 p.m. Semiconductors and Solid-State Devices I

DP Recent Advances in Transistor Development. *J. A. Morton*, Bell Laboratories

DP Transistor Reliability. *W. J. Pietenpol*, Bell Laboratories

DP High-Frequency Transistors with Emphasis on PNIP. *J. M. Early*, Bell Laboratories

DP Silicon Transistors. *J. L. Moll*, Bell Laboratories

DP Solar Batteries and Power Rectifiers. *A. E. Anderson*, Bell Laboratories

DP Alloy-Germanium Transistors. *J. J. Ebers*, Bell Laboratories

2:00 p.m. Computers I

Panel Session: Centralized vs. Decentralized Computers

The NORC—A Central Computer. *W. J. Eckert*, Watson Laboratories and Columbia University

Decentralized Computers. *Frank Verzuh*, Massachusetts Institute of Technology

Decentralized Input-Output with Central Computer. *H. R. J. Grosch*, General Electric Company

Friday, May 6

9:30 a.m. Semiconductors and Solid-State Devices II

DP Alpha Fall-Off in Fused Junction Transistors. *R. L. Bright*, Westinghouse Electric Corporation

DP High-Temperature Area-Type Dioxide Rectifiers. *H. C. Gorton* and *T. S. Shilliday*, Battelle Memorial Institute

DP Techniques for Measurement of Barrier Capacitance of Metallic Rectifiers. *K. E. Hassler* and *W. E. Bulman*, Battelle Memorial Institute

9:30 a.m. Computers II

DP Application of Electronic Computers to Flood Routing and Other Hydraulic Problems. *E. Lawler*, U.S. Army Corps of Engineers

DP Application of GEDA to Human Dynamics Studies. *H. L. Flowers*, Goodyear Aircraft Corporation

DP Design Studies of Large High-Performance Pressure Control Systems Using Analogue Computer. *G. Rowselit*, Hagan Corporation

DP Simulation of Mechanical Systems Coupled by Cams and Levers. *J. J. Stone*, *W. Hecox*, amd *J. K. Weatherbee*, Battelle Memorial Institute

9:30 a.m. Insulation for Rotating Machinery III

DP Magnet Wire Performance in Product Life Tests. *R. L. Balke*, General Electric Company

DP Insulation Evaluation Program and Equipment used for Medium-Sized Electric Machinery. *G. L. Moses* and *R. D. Wolford*, Westinghouse Electric Corporation

DP Guiding Principles in the Thermal Evaluation of Insulating Materials. *L. J. Berberich* and *T. W. Dakin*, Westinghouse Electric Corporation

DP The End Point in Motorette Testing. *G. A. Cypher* and *T. J. Gair*, General Electric Company

9:30 a.m. Electric Power Systems II

55-281 Grounding Grids for High-Voltage Stations II. *E. T. B. Gross* and *R. B. Wise*, Illinois Institute of Technology

55-282 Combination Load-Flow and Stability Equivalent for Power System Representation on A-C Network Analyzers. *W. T. Brown* and *W. J. Cloust*, Philadelphia Electric Company

DP55-283 Generator Loading Guides for Power System Operation. *R. H. Travers*, Ohio Edison Company and *I. H. Lander*, Commonwealth Associates, Inc.

DP Economic Study of Higher Voltages. *P. L. McVean*, Detroit Edison Company, and *J. G. Tarboux*, University of Michigan

DP Use of Higher Secondary Voltages in Commercial Areas. *R. F. Lawrence*, Westinghouse Electric Corporation

9:30 a.m. Aircraft Electric Systems I

DP Electric Systems Unique to Airships. *J. L. Lytle* and *R. Lyman*, Goodyear Aircraft Corporation

DP Electric Systems Unique to Fighter-Airplanes. *G. Godfrey*, North American Aviation, Inc.

DP Electric Systems Unique to Flying Boats. *W. Colehower*, Glenn L. Martin Company

DP Developments in Aircraft Exterior Lighting. *M. K. Laufer*, Grimes Manufacturing Company

DP Emergency Electric Systems for Aircraft. *M. Smollberg*, Marquardt Aircraft Corporation

2:00 p.m. Rotating Machinery IV

55-284 Equivalence Theorems—Analysis and Synthesis of Single-Phase Induction Motors with Multiple Nonquadratic Windings. *Sheldon Chang*, New York University

DP Motor Inertia Effect in the Operation of Air-Conditioning Compressors. *R. G. Rascorla*, General Electric Company

55-285 An Improved Electronic Speed-Torque Computer. *J. Shulman* and *H. W. Hansen*, Westinghouse Electric Corporation

DP Calculation of Impedance-Frequency Characteristics of Induction Motor Rotor Conductors. *J. E. Williams*, University of Illinois

55-286 Application of Statistics to Motor Testing. *J. L. Oldenkamp*, General Electric Company

2:00 p.m. Electric Power Systems III

DP The Role of Economics in System Planning. *Abraham Gerber*, American Gas and Electric Service Corporation

DP Planning the Power System I—General Considerations. *T. J. Nagel* and *C. A. Imburgia*, American Gas and Electric Corporation

DP Planning the Power System II—Examples of Technical Problems. *C. F. DuSiem*, American Gas and Electric Service Corporation

DP Economic System Loading. *G. W. Stagg*, American Gas and Electric Service Corporation

2:00 p.m. Aircraft Electric Systems II

DP Co-ordination Problems in A-C Systems. *H. K. Omer*, Westinghouse Electric Corporation

DP55-346 Environmental Free Machines and High Temperature Problems of Rotating Equipment. *O. E. Buxton*, Jack and Heintz, Inc.

55-287 Design and Protection of A-C Power Systems for Aircraft Instruments. *O. Markowits* and *K. Sears*, Naval Air Development Center, Johnsville, Pa.

2:00 p.m. Computers III

DP Special Analogue Computer. *G. D. McCann*, California Institute of Technology

DP Improved Servomultipliers for Analogue Computers. *E. H. Gamble*, General Electric Company

DP Quasi-Random Access Memory Systems. *G. L. Hollander*, Clevite Brush Company

DP Magnetic Computer Components. *R. D. Kachi*, Raytheon Manufacturing Company

DP55-351 Reliability of Computer Tubes. *E. S. Mockus*, Raytheon Manufacturing Company

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Variety of Inspection Trips Scheduled for AIEE Summer Meeting

Plans for the 1955 Summer General Meeting to be held June 27 to July 1 at the New Ocean House, Swampscott, Mass., are nearing completion. A broad informative program is assured and Mr. A. M. Bjontegard, chairman of the Trip Committee, reports that the following tours are scheduled:

Champion-International Paper Company, Lawrence, Mass. Champion-International is a leading manufacturer of high-quality coated papers for the fine printing industry. Visitors may watch the entire paper making procedure from pulpwood to gleaming white sheets of paper.

Measurements Laboratory, General Electric Company. This measurements laboratory is one of the most modern and best equipped, including: test facilities for shock, vibration and noise, environment and high voltage. In addition to physics, chemistry and magnetics laboratories, the instrument department maintains management, marketing, and engineering offices here.

Medium Steam Turbine, Generator, and Gear Department, General Electric Company, River Works, Lynn, Mass. The medium steam turbine, generator, and gear department has manufactured over 21,000,000 kw of power-generation equipment since 1903. Visitors may observe the heavy machine work and assembling and testing of turbines and generators.

Harvard University and Massachusetts Institute of Technology (MIT). The trip to these institutions will include guided tours through specific buildings and laboratories for electrical engineering work. The numerically controlled milling machine in the servomechanisms laboratory at MIT will be demonstrated.

Saugus Iron Works, Saugus, Mass. Built originally in 1646, this colonial iron works was the first successful and sustained producer of cast and wrought iron in the New World. It was recently restored at a cost of more than $1,000,000. A replica of the original stone blast furnace with its 16-ft water wheel and giant leather bellows is featured.

Boston Naval Shipyard. This trip to one of the oldest shipyards in the United States will include a harbor excursion for a view of the mothball fleet and dry-dock facilities. In addition, a large naval vessel and the frigate "Constitution" will be visited.

Electronics Division, Sylvania Electric Products, Inc., Woburn, Mass. A broad line of semiconductor devices and microwave components, such as klystrons, magnetrons, silicon and germanium diodes, flash tubes, and thyratrons are manufactured in this division.

United States Coast Guard Air Station, Salem, Mass. Demonstrations and explanations of various equipment and techniques used in air-sea search and rescue operations are scheduled. This station has an outstanding record of marine rescue operations in an area extending from Newfoundland to Bermuda.

General Radio Company, Cambridge, Mass. The General Radio Company is one of the best known manufacturers of electronic test equipment and associated high-precision apparatus. This trip includes inspection of all the laboratories and methods used for small-lot production as they apply to electronic instrument manufacture.

TOURS FOR THE LADIES

Mrs. Mark A. Princi, chairman of the Ladies Activities Committee, has plans well under way. On Monday, June 27, a get-acquainted tea is planned, and on Tuesday, June 28, a sightseeing tour will be made of historic places in Boston. This will be fol-

THE SAUGUS IRON WORKS (shown above) is on the list of inspection trips for the Summer General Meeting. Originally built in 1646, this colonial iron works was the first successful and sustained producer of cast and wrought iron in the New World. It has been restored at a cost of more than $1,000,000

lowed by a trip with the men to Harvard and MIT. The Saugus Iron Works will be visited Wednesday morning, June 29, and in the afternoon a shopping and sightseeing tour of Marblehead is planned. Thursday's trip for the ladies will be to Rockport and the Hammond Castle. Lunch will take place at Castle Hill, Ipswich.

HOTEL RESERVATIONS

Hotel Committee Chairman R. E. Franck urges members to make reservations early. They will be taken on a "first come-first served" basis. Mail your reservations directly to the New Ocean House, Swampscott, Mass., stating that the reservation is for the 1955 AIEE Summer General Meeting. Arrangements have been made for other hotels in surrounding towns to take care of overflow. Transportation will be furnished to and from the New Ocean House for those at outlying hotels, for a small fee. Rates will be from $11.00 to $14.00 per day, including meals. Plenty of space is available, with the exception that the number of single rooms is limited. Some fine motels are also located nearby. Anyone interested in this type of accommodation should contact R. E. Franck, General Electric Company, West Lynn Works, Lynn, Mass.

ASME Commemorates 75th Anniversary of the Society's Founding in 1880

The first of a series of meetings this year to commemorate the founding of The American Society of Mechanical Engineers (ASME) was held February 16. Theme of the meeting was "The Engineer and the World of Communications." The commemorative session was held in the McGraw-Hill Publishing Company auditorium. The ASME was founded 75 years ago, in the office of *American Machinist*, now a McGraw-Hill publication. In the afternoon, a panel, "The Engineer and His Communications," was held at the Engineering Societies Building and was followed by a dinner at the Waldorf-Astoria. Various honors were conferred at the dinner. General society meetings during the remainder of the year at Stevens Institute of Technology and in the cities of Baltimore, Boston, and Chicago will be devoted to various facets of the broad theme "The Engineer in Our World" and his relation to education, government, science, and the world of commerce and industry.

COMMEMORATIVE SESSION

Ceremonies were opened by General Chairman Burnham Finney, editor of *American Machinist*, who was followed by Donald McGraw, president, McGraw-Hill Publishing Company, who gave the welcome address.

Greetings were presented to ASME from a number of associations and societies representing the various communications media: fields of journalism, broadcasting, book publishing, public relations, and advertising.

An address, "Mechanical Engineers and Communications" was presented by David W. R. Morgan, president, ASME. Mr. Morgan related the ideals and principles set down by the early founders to the growth and contributions of the society to enrich mankind in the past 75 years. Tribute was paid to the unselfish voluntary efforts of the engineers working through the society to serve mankind.

Also, a plaque was presented to the McGraw-Hill Publishing Company commemorating the founding of the ASME in the office of the *American Machinist*.

At the conclusion of the ceremonies, R. H. Phelps, director of the Engineering Societies Library, described the library and its functions. The library now contains approximately 170,000 volumes and receives 1,400 periodicals. A tour of the library took place before the afternoon session.

THE ENGINEER AND HIS COMMUNICATIONS

The aspects of the engineer and his communications were presented by a panel of four prominent speakers. First speaker was Edgar Kobak, president of the Advertising Research Foundation. He dealt with the engineer's communications outside his profession. Attention was drawn to the poor publicity sense of engineers as compared with the medical and scientist groups; but Mr. Kobak urged engineers not to sacrifice engineering in favor of promotion or publicity. He thought a better job should be done to make their works and themselves better known, however.

James G. Lyne, president, Simmons-Boardman Publishing Company, spoke of the engineer's communications with other engineers, and Ormand J. Drake, assistant secretary of New York University, dealt with aspects of effective spoken communications. An effective speech is made from the mind, the heart, and the audience. The message must be worth giving and there must be an earnest desire to communicate. The audience was considered as a catalyst. "What the Engineer Has Meant to Communication" was presented by Dr. E. W. Engstrom, executive vice-president of research and engineering, Radio Corporation of America. Dr. Engstrom drew attention to nine different systems of communication which were nonexistent when the ASME was founded. In the next 75 years, Dr. Engstrom predicted, there will be a high degree of development of solid-state devices, advances in personal communication, more efficient use of communications channels, data processing, and data processing machinery which would respond to the spoken word. Full text of the address appears on pp. 274–7.

Willard T. Chevalier, who presided, said that the whole question of world peace and world security today is becoming a problem of communication. Too much of today's communication, however, consists of words and not of ideas.

DINNER

The dinner was held in the evening, preceded by a social hour. Toastmaster was William L. Batt, formerly minister for economic affairs to Great Britain and past-president of ASME.

The 1955 Worcester Reed Warner Medal bestowed for outstanding contributions to permanent engineering literature was presented to Howard S. Bean, chief of the ca-

HONORARY MEMBERSHIP was awarded to Vannevar Bush (left), president, Carnegie Institution of Washington, in The American Society of Mechanical Engineers at the society's recent founding meeting celebration. W. L. Batt, (center) was toastmaster, and H. S. Bean, (right) physicist, National Bureau of Standards, received the Worcester Reed Warner Medal

pacity, density, and fluid meters section, National Bureau of Standards. The medal was presented "for his valuable contributions to the art and science of fluid metering and his unselfish work in preparing the many authoritative publications on this subject, particularly the widely used reports of the ASME Fluid Meters Research Committee."

Honorary Membership was conferred upon Dr. Vannevar Bush with the citation "Eminent engineer, beloved teacher, brilliant national leader in research in the physical sciences, prophetic seer of things to come, inspiring organizer of engineering and science in the national emergency." Dr. Bush is president of the Carnegie Institution of Washington. The subject of his address was "Communications—Where Do We Go From Here?" Advances in the art of communication were reviewed, as well as the need for a data processing system to facilitate library research, and the need of improved communications in relation to the international situation. Full text of Dr. Bush's address is scheduled for the May issue of *Electrical Engineering*.

Telemetering Conference Will Take Place Next Month

The 1955 National Telemetering Conference will take place May 18, 19, and 20 at the Hotel Morrison in Chicago, Ill. The conference, sponsored by AIEE, the Institute of Radio Engineers, Institute of the Aeronautical Sciences, and the Instrument Society of America, will feature a full program of technical papers and exhibits in the fields of: industrial telemetering, pickups and transducers, telemetering components, data processing, flight testing, multiplexing techniques, and new developments in telemetry and remote control.

Dr. Hugh L. Dryden, director, National Advisory Committee for Aeronautics, will be banquet speaker. His subject will be, "Problems in Ultra High Speed Flight." Dr. W. A. Wildhack, of the National Bureau of Standards, will be luncheon speaker. Dr. Wildhack's subject will be "Inaccurate Transmission of Misinformation."

Inquiries regarding exhibits should be addressed to G. Brittain, Armour Research Foundation, Chicago, Ill., and inquiries regarding program to Conrad H. Hoeppner, Stavid Engineering, Inc., Plainfield, N. J.

Advance Program

Wednesday, May 18

Morning Session: Components I Industrial Telemetering

Chairman: K. C. Black

A New Hi-Speed Telemeter Transmitter for D-C Measurements. *R. M. Stuart*, General Electric Company

A New Electronic Telemetering Transmitter for Pilot Wire Applications. *T. Barabutsz*, Westinghouse Electric and Manufacturing Company

An Incremental Remote Position Control System. *Jonathan Mass*, Kiryat Motzkin

A New Time Interval Telemeter System. *W. H. Howe*, The Foxboro Company

Afternoon Session Systems I Industrial Telemetering

Chairman: P. A. Borden

Pulse Telemetering for Industry. *V. C. Kennedy, Jr.*, Streeter-Amet Company

Automatic Teletype Transmitting System. *J. R. Cunningham*, Beckman Instruments, Inc.

Ultra Sonic Liquid Level Indicator System. *R. L. Rod*, Bogue Electric Manufacturing Company

Channels for Telemetering, Supervisory Control, and Other Purposes. *H. A. Rhodes*, American Telephone and Telegraph Company

Telemetering System for Space Position Data. *R. N. Nicola*, The Newton Company

Components II Pick-ups and Transducers

Chairman: K. M. Uglow

Vibrotron Digital Telemetering System. *J. Ohman*, Southwest Research Institute

A Commutatorless D-C Motor. *H. D. Brailsford*, Brailsford and Company, Inc.

Precision Data Recording and Repeating System (The Inductosyn). *J. L. Winget*, Farrant Optical Company

A Gravity Switch. *P. Weaver*, The W. L. Maxson Corporation

A Phase Modulated Transistorised Pressure or Acceleration Telemetering Channel. *A. I. Drantz, J. L. Upham*, Gulton Manufacturing Corporation

New Developments in Miniature Telemetering Pickups. *L. A. G. TerVeen*, Bendix Aviation Corporation

Thursday, May 19

Morning Session Systems II Flight Testing

Chairman: C. A. Taylor

New AKT-6 Flight Test. *J. E. Spooner*, Radiation, Inc.

Telemetry as a Flight Test Instrument. *J. J. Dover*, Air Force Flight Test Center, Edwards Air Force Base

A PDM-FM Telemetering System for Low Level D-C Inputs. *R. H. White*, National Advisory Committee for Aeronautics

An Analogue Cross-Spectrum Analyzer for Telemetering. *R. L. Kenimer*, National Advisory Committee for Aeronautics

Automatic Digital Recording of Flight Test Data. *L. I. Goldfischer, S. G. Cohen*, General Precision Laboratories

Afternoon Session Systems III Multiplexing Techniques

Chairman: E. L. Gruenberg

Mechanical Sampling Devices in Telemetering and Related Fields. *J. P. Brinster*, General Devices, Inc.

A New Subminiature Airborne FM Demultiplexer. *L. Finkel, F. Shandelman, J. Piontkowski*, Raymond Rosen Engineering Products, Inc.

The Magnetron Beam Switching Tube. *H. Mass*, Burroughs Corporation Research Center

A Mercury Jet Commutating Switch. *W. R. Davis*, Detroit Controls Corporation

Miniaturized Airborne Electronic Commutator. *R. O. Du Bois*, Electro-Mechanical Research, Inc.

Telemetry Filters and Their Effect on the Dynamic Accuracy of Multiplex FM Subcarrier Instrumentation Systems. *G. S. Sloughter, R. A. Runyan, W. H. Duerig, G. E. Tisdale*, Electro-Mechanical Research, Inc.

Components III New Developments in Telemetry and Remote Controls

Chairman: J. T. Mengel

Mixing Airborne Telemetering Subcarriers for Maximum Isolation with Minimum Loss. *W. F. Link*, Bendix Aviation Corporation

A New Ground Station Telemetering Receiver. *M. S. Roiden, H. W. Zoncanta*, Nems-Clarke, Inc.

The Use of A-C Excited Gauges in a PDM/FM Telemeter System. *W. F. Carmody*, Boeing Airplane Company

A New Instrumentation Direct Writing Recorder and its Application to Telemetry. *G. E. Bower*, Century Electronics Company

Precision Multi-Channel Heads for Magnetic Tape Recording. *A. V. Gangnet*, Ampex Corporation

A Digital Approach to Telemeter Testing. *C. R. Reid*, Goodyear Aircraft Corporation

An Automatic Landing System for Aircraft. *M. H. Goldstein, Jr., C. W. Merriam III*, Massachusetts Institute of Technology

Dinner

Speaker: Dr. Hugh L. Dryden, National Advisory Committee for Aeronautics. **Problems in Ultra High Speed Flight**

Friday

Morning Session
Systems IV

Chairman: W. J. Mayo-Wells

New Developments in Telemetry and Remote Control Radar Beacon Telemeter. *J. W. Polizo*, Stavid Engineering, Inc.

Flight Control Group AN/DRA-2. *W. H. Eggerton*, Melpar, Inc.

A Pulse Telemetering System for Use on Balloon-Launched Rockets. *L. R. Davis*, Naval Research Laboratory

The AN/DKT-4 and AN/MKR-1 Telemetering System. *T. B. Jackson*, U. S. Naval Ordnance Laboratory

Silicon Transistor Applications in Telemetering Equipment. *C. E. Earhart, O. A. Becklund*, Texas Instruments

Coherent Pulse Telemetry. *A. H. Cooper*, E. M. I. Engineering Development, Ltd.

Luncheon

Speaker: Dr. William A. Wildhack, National Bureau of Standards. **Inaccurate Transmission of Misinformation**

Afternoon Session
Components IV
Data Processing

Chairman: C. F. West

The Role of Magnetic Tape in Data Recording Processing and Analysis. *G. L. Davies*, The Davies Laboratories, Inc.

Talking to a Computer. *R. F. Shaw*, Underwood Corporation

A Precision Pressure Telemetering System with Digital Data Handling. *J. Prast*, Bell Aircraft Corporation

An Automatic Digital Data Reduction System Utilizing PDM Telemetering. *R. F. Hummer, R. M. McClung, D. J. Simmons*, Aviation Ordnance Department

Data Reduction Equipment Used with the FALCON Missile. *H. D. Greif*, Hughes Aircraft Company

Registration forms will be available early this month (April) and are to be sent to the registration chairman, Mr. John Gorey, Lindberg Engineering Company, 2540 Hubbard Street, Chicago, Ill.

Tuesday, May 10

9:00 a.m. Morning Session

Presiding: Harold Bunte, Commonwealth Edison Company, chairman, AIEE Committee on Electric Heating

Welcoming Address: Harold R. Heckendorn, Western Electric Company, chairman, AIEE Chicago Section

Technical Session Chairman: T. P. Kinn, consultant, chairman, AIEE Subcommittee on Induction and Dielectric Heating

Furnace Brazing. *H. M. Webber*, General Electric Company

A New Heating Method for Brazing Aluminum and Magnesium. *W. C. Rudd*, New Rochelle Tool Corporation

New and Unusual Applications of the Salt Bath Furnace. *L. B. Rosseau*, Ajax Electric Company

Progress in Industrial Radiant Heating. *E. J. Bates*, National Cash Register Company

1:30 p.m. Afternoon Session

Technical Session Chairman: *E. J. Bates*, National Cash Register Company, chairman, AIEE Subcommittee on Radiant Heating

Vacuum Melting in Large Quantities. *J. D. Nisbet*, Universal Cyclops Steel Company

Fields of Application of 60-Cycle Core-Type Induction Melting Furnaces in the United States. *Manuel Tama*, Ajax Engineering Corporation

Fundamentals of Metallurgy Involved in the Heating and Melting of Metals—Both Ferrous and Nonferrous. *N. K. Korbel*, Lindberg Engineering Company

Metal Sheath Resistor Type Heating. *C. F. Kreiser*, E. L. Weigand and Company

Making Electric Heat Easy to Use. *G. E. Duerr*, West Penn Power Company

6:30 p.m. Banquet

8:00 p.m. Evening Session

Presiding: Harold Bunte, Commonwealth Edison Company, chairman, AIEE Committee on Electric Heating

Atomic Energy—Weapon for Peace. Dr. H. N. Alyea, Princeton University

Wednesday, May 11

9:00 a.m. Morning Session

Technical Session Chairman: *W. C. Rudd*, New Rochelle Tool Corporation, vice-chairman, AIEE Committee on Electric Heating

60-Cycle Heating of Metals. *B. E. McArthur*. Magnethermic Corporation

Dual Frequency Heating for Forging. *C. A. Tudbury*, The Ohio Crankshaft Company

Induction Heating for Automatic Forging. *K. J. Surace*, Lamson and Sessions Company

Scale Model Testing Applied to Induction Heating. *R. M. Baker*, Westinghouse Electric Corporation

1:30 p.m. Afternoon Session

Technical Session Chairman: *R. W. Kise*, General Electric Company, secretary, AIEE Committee on Electric Heating

High Frequency Resistance Heating. *H. J. Cameron*, New Rochelle Tool Corporation

Case Experiences with Interference Reduction for F. C. C. Certification. *T. P. Kinn*, consultant

Dielectric Heating in Processing of Saran. *F. H. Justin*, Dow Chemical Company

New Applications of Dielectric Heating. *W. H. Hickok*, The Girdler Corporation

Announcement of Price Increases for Volume 74 of the 1955 AIEE Transactions

Because of the increased number of papers published in AIEE *Transactions* and the resulting increased number of pages, member subscription price to sets of all four parts will be $9.00 annually. This will begin with Volume 74 of the 1955 *Transactions*. The price has been $6.00 annually. Also, because of the increased number of papers and pages in Part III, *Power Apparatus and Systems*, it has been necessary to divide this part into two parts—III-A and III-B—for more convenient handling. Total increase in the number of papers and pages in all three, or four parts, is shown in the table.

	1952	1953	1954	Per Cent Increase
No. of papers	284	388	461	62.4
No. of pages	2,076	2,732	3,040	46.5

The annual nonmember subscription to both *Electrical Engineering* and AIEE *Transactions* has been advanced from $16.00 annually to $20.00 (effective April 1, 1955). Two dollars extra will now be charged for foreign postage. Both the subscription price and the postage, $22.00, are payable in advance in New York exchange.

The AIEE *Transactions*, bound in cloth with a stiff cover, contains all officially approved technical papers with discussions at meetings during the year. The parts, each separately indexed (except Part III-A) beginning with Volume 73 for 1954, are as follows:

Part I. Communication and Electronics
Part II. Applications and Industry
Part III-A. Power Apparatus and Systems
Part III-B. Power Apparatus and Systems

There is no change in the price of single parts: $3.00 per part to members and $6.00 per part to nonmembers including 75¢ extra for foreign postage. Again, both the subscription and postage are payable in advance in New York exchange.

Discounts of 25 per cent of nonmember prices to college and public libraries are allowed. Publishers and subscription agencies are allowed a 15 per cent discount of the nonmember prices. Please send all orders to: Order Department, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y.

2-Day Electric Heating Conference Set for May 10 and 11 in Chicago, Ill.

Subjects to interest everyone in the industrial heating field will be featured at the 2-day Electric Heating Conference sponsored by the AIEE Committee on Electric Heating. The Conference will be held at the La Salle Hotel in Chicago on May 10–11, 1955. As a particular feature, papers will be presented to each registrant in book form.

Dr. Hubert N. Alyea, professor of chemistry, Princeton University, a leading authority on atomic energy, will present the banquet address on the evening of May 10. Dr. Alyea's subject will be "Atomic Energy—Weapon for Peace." He will discuss the subject in all its ramifications, past and future.

W. J. Barrett Becomes President of UET

United Engineering Trustees, Inc. (UET) installed Walter J. Barrett as president, February 24. Mr. Barrett represents AIEE on the board of trustees. He is also Treasurer and a Director of the Institute, and a director of Engineers Joint Council. Mr. Barrett is electrical co-ordination engineer with the New Jersey Bell Telephone Company.

He has been a member of the board of trustees for 4 years, serving as vice-president and on various committees. He is taking office as president of the corporation at a particularly critical time, when a new and larger engineering center is being considered. Various cities are offering attractions to move the engineering headquarters from New York.

UET was established 51 years ago to advance the engineering arts and sciences in all branches, and to maintain a free public engineering library. It is the owner of the Engineering Societies Building given by Andrew Carnegie in 1904. Its Founder Societies are AIEE, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and The American Society of Mechanical Engineers. (For Mr. Barrett's other activities, see page 356.)

Revised Program Announced for Rubber and Plastics Conference

A revised program has been announced for the Seventh Annual AIEE Conference on Rubber and Plastics to be held at the Mayflower Hotel, Akron, Ohio, Monday and Tuesday, April 4 and 5. Theme of the conference is "Automation in Rubber and Plastics Industries." The Subcommittee on Rubber and Plastics of the Committee on General Industry Applications is sponsor.

Subcommittee chairman is W. S. Watkins. Secretary-treasurer for the conference is Robert Condon, and R. D. Heyburn is chairman of the Local Arrangements Committee.

Monday, April 4

Registration:

8:00—9:15 a.m.

Morning—9:15 a.m.

Keynote Address: What Does Automation Mean to a Processing Industry? *E. S. Lee*, Past-President AIEE, General Electric Company

The Status of Automation in the Rubber and Plastics Industries. *G. V. Kullgren*, Hale and Kullgren, Inc.

Electric Drives for Rayon and Nylon Tire Fabric Machines. *C. E. Robinson*, Reliance Electric Company

Afternoon—2:00 p.m.

Comparison of Rubber Calender Thickness Gauges. *R. F. Snyder*, Goodyear Tire and Rubber Company

Automatic Weighing Systems—A Symposium.

Application Problems of an Automatic Weighing System. *R. V. Fisch*, The Ohio Rubber Company

Electric Transducers for Automatic Weighing. *R. E. Bell*, Toledo Scale Company

Hydraulic and Pneumatic Transducers for Automatic Weighing. *J. C. Williams, Jr.*, Weighing Components, Inc.

Dial Scale Instrumentation in Automatic Batch Weighing. *W. M. Young*, Richardson Scale Company

Evening—6:30 p.m.

Banquet, Mayflower Hotel Ballroom

Introduction: W. H. Sammis, Ohio Edison Company
Speaker: J. E. Trainer, Firestone Tire and Rubber Company

Tuesday, April 5

Morning—9:00 a.m.

Comparison of Rotating Electronic Regulators and Magnetic Amplifiers Regulators. *J. P. Montgomery*, Westinghouse Electric Corporation

Report of Special Committee on Electric Equipment in Contaminated Atmospheres. *E. L. Smith*, Firestone Tire and Rubber Company

Application and Design Considerations of A-C Motors in Rubber and Plastics Industries. *C. E. Miller*, General Electric Company

Closing Paper: Automatic Control Centers for Industrial Processing. *Paul Dicke*, Bailey Meter Company

Afternoon

Inspection Trip: Timken Roller Bearing Company, Canton Ohio (Reservations by 6:30 p.m., April 4)

Conference on Electrical Techniques in Medicine, Biology

The Eighth Annual Technical Conference on Electrical Techniques in Medicine and Biology will be held in November, 1955. The Conference is jointly sponsored by AIEE, the Institute of Radio Engineers, and the Instrument Society of America. Tentative plans call for holding the conference in Washington, D. C.

The conference serves as a meeting place for physiologists, biologists, cardiologists, radiologists, physicians, physicists, electronic, electrical, and instrument engineers. A large portion of the registration is drawn from the research groups in universities and industry.

Authors are invited to submit titles of papers for consideration by the Program Committee to E. Dale Trout, conference chairman, 4855 Electric Avenue, Milwaukee 1, Wis.

Magnetics Conference and Exhibit Scheduled for June 14–16, 1955

The Magnetics Subcommittee of AIEE's Basic Science Committee, in co-operation with the American Physical Society and the American Institute of Mining and Metallurgical Engineers, has arranged a Conference and Exhibit on Magnetics to take place June 14–16, at the William Penn Hotel in Pittsburgh, Pa.

Plans are to have six sessions devoted to the following subjects: magnetic materials, metallurgy of magnetic materials, mechanism of magnetization, application and manufacturing of soft materials, permanent magnets, measurements and techniques, ferrites, high-frequency switching, and storage of information.

The exhibit is under the direction of the Exhibit Committee of the Magnetics Subcommittee with Mr. John Osborn as chairman and Mr. Richard Rimbach (845 Ridge Avenue, Pittsburgh 12, Pa.) as manager. Mr. Rimbach has managed many successful industrial shows.

This conference and exhibit will bring together those interested in basic and applied work on magnetism and magnetic materials. Manufacturers of soft magnetic materials and permanent magnets, cores and core materials, ferrites, magnetic analysis equipment, magnetizers and demagnetizers, magnetic recording equipment and tapes, magnetic amplifiers, saturable reactors, etc., will, therefore, be provided with an audience of the most influential engineers and scientists most directly concerned with their products.

Branch at Missouri Mines Hears Speakers from Industry

The AIEE-Institute of Radio Engineers Student Branch at the Missouri School of Mines heard W. F. Schmidt, Jr., junior engineer, Vickers Electric Division, Vickers, Inc., St. Louis, Mo., speak on "Magnetic Amplifiers" at the December 9 meeting. His paper included the design, construction, and application of magnetic amplifiers in industry today.

On January 12 the Branch met with The American Society of Mechanical Engineers' student group to hear L. J. Linde deliver his paper, "Young Engineers at Work." Mr. Linde is assistant general manager and chief engineer, Allis-Chalmers Manufacturing Company, Hyde Park, Mass. The talk pointed out the opportunities for young engineers and what they may expect in industry.

Plans for the remaining programs of the year emphasize student papers and membership.

Speakers Announced for Electronics Components Conference

Two major luncheon addresses and a novel banquet "debate" will be features of the 1955 Electronics Components Conference to be held in the Ambassador Hotel, Los Angeles, Calif., May 26–27.

Dr. Ivan Getting, vice-president, Raytheon Manufacturing Company, will address the conference at luncheon on May 26. His talk will trace the rapidly growing importance of components to over-all electronic systems planning and the program for accelerated component development.

That evening, at the conference's banquet meeting, a unique debate "Tubes versus Transistors," will include Dr. W. R. G. Baker, vice-president, General Electric Company, and Major General C. S. Irvine, Deputy Commander of the Air Materiel Command, who will argue on behalf of tubes; and Dr. Louis Ridenour, vice-president, International Telemeter, and Dr. Harper North, Pacific Semi-Conductors Inc., on behalf of transistors.

On May 27, the conference luncheon speaker is to be Dr. John Von Neumann, Institute for Advanced Study, who will discuss "The Ideal Computer Component of the Future."

In all, about 60 technical papers on components are to be presented during the 2-day conference.

AIEE Fellows Honored New York Section

ELECTRICAL ENGINEERS of the New York Section who were present at a dinner, January 12, to honor Section members who have become Fellows of the Institute during 1953 and 1954. A Section meeting followed the dinner. Seated (left to right): C. H. Cramer (F '53); L. M. Hull (F '54); J. V. L. Hogan (F '54); J. R. Kerner, Section chairman; W. D. Cannon (F '54); C. T. Hatcher (F '54); and A. G. Clavier (F '53). Standing are the following: H. H. Haglund; E. F. DeTurk (F '54); M. D. Hooven; R. M. Franklin; V. M. Marquis (F '54); H. A. Enos (F '54); O. E. Buckley; W. T. Rea; G. F. Maedel; H. A. Batzold; W. Z. Clark; V. Antofilli; L. F. Stone; F. W. Gilman; W. O. Arnold; J. D. Tebo; Institute Secretary N. S. Hibshman; J. W. Emling; L. F. Hickernell; F. A. Russell; W. J. Barrett; Vice-President J. P. Neubauer; M. A. Townsend; C. S. Purnell; F. W. Mahley; R. W. Weil; P. C. Goldmark (F' 54); J. E. Dingman (F '54); E. B. King; J. J. Anderson; A. R. Gatewood

Villanova Students Learn About Building Construction on Campus

Villanova students learned the "inside" story of the new Student Union Building now under construction at a meeting last December 6, sponsored by Student Branches of the AIEE, Institute of Radio Engineers (IRE), American Society of Civil Engineers, and The American Society of Mechanical Engineers. Speakers were: Mr. Henry Dagit, architect for the new building, Mr. Joseph R. Farrell, contractor for the job, and a panel of several representatives of the subcontractors.

Mr. Dagit told of many innovations in the building design and factors entering into over-all design. He also discussed legal factors associated with the preparation of the contracts needed for the project and mentioned ethical responsibilities of the engineer in industry.

Mr. Farrel spoke about the actual construction of the building and mentioned some unique problems that have arisen. Panel members spoke individually about their particular jobs. One man presented a discussion of the air-conditioning system, another the electric power supply and illumination, a third, plumbing, etc.

The AIEE and IRE branches also sponsored their first "Ladies Night" December 16. The program concerned high-fidelity sound reproduction. This was thought to be a technical subject of interest to the ladies. The campus was decorated for the holidays and music from Christmas records, on a high-fidelity system, was piped outside.

Thomas W. Morling, a Villanova graduate now with the Audio Components Division of General Electric Company, Syracuse, N. Y., was guest speaker. Mr. Morling traced the history of the phonograph and mentioned some of the factors that enter into design of a complete high-fidelity system, including the pickup, preamplifier, amplifier, and loud speaker. In regard to design, he told of some of the problems confronting the engineer in his own work and the compromises that must be made in making a finished product.

Other engineering societies at Villanova, as well as student nurses, and faculty members of the School of Engineering, were invited to attend.

AIEE Has Appointed 1 of 12 NBS Advisory Committees

During the past year, 12 technical area advisory committees have been established to provide a direct continuing link between the National Bureau of Standards (NBS) and the organized science and technology of the nation. AIEE is one of nine scientific and engineering societies that have nominated advisory committees to the Bureau in the fields of physics, chemistry, mathematics, metallurgy, ceramics, and electrical, radio, civil, and mechanical engineering. In addition, the National Conference on Weights and Measures, the American Society for Testing Materials, and the American Standards Association have designated groups at the Bureau's request to advise in their areas of special interest.

The AIEE advisory committee, with Dr. Ralph Bown of Bell Telephone Laboratories as chairman, will consider programs in electricity and electronics. The work in electricity is primarily concerned with development and improvement of standards and methods of measurement for all electrical quantities. Research in electronics at the NBS is directed toward obtaining knowledge of basic electronic phenomena and the properties of materials of potential significance to electronics. Developmental work in the electronic field includes not only design of circuitry for performance of new functions—such as various components of high-speed electronic computers—but also for the broader phases of fabrication technology by which optimum designs for electronic equipment may be achieved.

Louisiana Tech Branch Visits Dallas, Texas, for Field Trip

Thirty-four members of AIEE's Student Branch at Louisiana Polytechnic Institute (Ruston) took a bus to Dallas, Tex., last December 13. In Dallas the students toured Chance Vought Aircraft, Collin's Radio Company, and the Texas Instrument Company. Personnel of the companies acted as guides and detailed accounts of the various operations were explained. Accompanying the group were electrical engineering professors M. R. Johnson, advisor, and A. C. Thigpen.

Admiral K. M. McManes Is Speaker at Michigan Section

"To survive...we must maintain our world leadership in technical developments and in the potential to implement and produce their results." This is the opinion of Admiral K. M. McManes, U. S. Navy, assistant chief of Naval Operations (Naval Reserve). Admiral McManes spoke before the Michigan Section, February 8.

He said that to maintain our world leadership in technical research and developments

AT DINNER MEETING of the Michigan Section, February 8, were: (seated left to right): Lt. Comdr. R. F. White, commanding officer, Jackson Naval Reserve training center; J. J. Carey, Section chairman; Adm. McManes, guest speaker; and G. W. Swanson, who introduced Adm. McManes. Standing (left to right): Section Secretary-Treasurer H. R. Armstrong; Vice-chairman F. Von Voightlander; and Lt. Art Linne, aide to Adm. McManes

it has been estimated that the U. S. needs about 40,000 engineering graduates each year. The present supply is 12,000 to 17,000. He believes this shortage could be alleviated to some degree by greater recognition of individuals who have accomplished outstanding engineering works. "The engineer thus recognized is not only regarded for his contribution to the profession and the nation, but is encouraged to greater performance and serves as an inducement to others to enter this field."

Besides technological achievement, Admiral McManes said we need a reservoir of trained personnel. "The economic welfare must not be sacrificed for military preparedness, and military preparedness must not be sacrificed for economic considerations. . . .The key to maintaining this difficult balance is the military and naval reserve. It is a weapon of our economy as well as a weapon of war. It is America's answer to the proposition that a long period of tension and military preparedness would bring us into financial ruin. Our active forces have already been reduced in the face of an international situation whose dangers have not diminished. To partially compensate for the reductions in our regular forces, we must have a reserve of greater strength and of higher caliber than any which we have had in the past. . . .An age of atomic weapons, supersonic aircraft, and guided missiles poses new and exacting demands. In order to be effective, reserves will have to acquire many new and more complex skills than ever before."

Automation, Quality Control, Topics at SAE Production Forum

Automation, quality control, and other manufacturing techniques were topics at the Society of Automotive Engineers' (SAE) Golden Anniversary Production Meeting and Forum. The meeting, one of 10 SAE Golden Anniversary affairs, was held March 14–16 in the Netherland Plaza Hotel, Cincinnati, Ohio. Sponsors were SAE's Engineering Materials Activity, the Production Activity, and the Cincinnati Section.

The forum was for exchange of information between automotive engineers. Audience discussion of day-to-day problems was encouraged. Eight panel meetings took place on March 14, presentation of technical papers March 15, and tours of Cincinnati manufacturing plants March 16.

700 Attend Transistor Circuits Conference February 17–18

Approximately 700 engineers attended the 2-day national conference on transistor circuits held in Philadelphia, Pa., Feb. 17–18. The conference was under the joint sponsorship of the Science and Electronics Division of AIEE, the Professional Group on Circuit Theory of the Institute of Radio Engineers, and the University of Pennsylvania. It was patterned after the first one held a year ago. A third conference is planned for February 16 and 17, 1956, also to be held in Philadelphia.

Nineteen papers were presented in four consecutive sessions covering both linear and nonlinear transistor circuit applications. The program was designed to be of greatest value to engineers who already possessed some knowledge of transitor circuit behavior.

Following the cocktail party and buffet dinner, February 17, five informal discussion groups were organized on subjects suggested by engineers attending the conference. This idea of informal discussion groups was experimental, but interest was so great that future plans will make them an important scheduled event.

AIEE-IRE Villanova Student Members Hear Two Alumni Speak

Two alumni, Henry Wu and Louis Ricciuti, were speakers at the Villanova Student Branch meeting, February 14. Both do research for the Polyphase Corporation on close-tolerance filters.

Mr. Wu discussed the fundamental theory of filter circuits and the classification of filters according to their function or components. Mr. Ricciuti traced the progression of one of their design projects starting with the customer's specifications. He outlined procedure followed in setting up the project and solving problems that arose. He also mentioned mechanical specifications such as temperature, pressure, humidity, and vibration extremes.

Figures Published on 1955 Engineering Graduates

The following figures may be of interest to members. They come from the January 21 *Engineering and Scientific Manpower Newsletter*, issued by the Engineering Manpower Commission of Engineers Joint Council, New York, N. Y., and the Scientific Manpower Commission, Washington, D. C. These figures concern the 150 schools with ac-

MEMBERS OF THE NATIONAL COMMITTEE for the 1955 Conference on Transistor Circuits get together during the buffet dinner before the meeting, February 17. Front row (left to right): N. Johnson. R. S. Gardner, H. E. Tomplins, and J. G. Brainerd. Back row (left to right): D. G. Fink. L. H. Good, and W. H. Forster

credited curricula only. Curricula breakdown is unavailable for nonaccredited schools. However, approximately 2,529 bachelor degrees and 47 master degrees will be awarded. Estimates of the effects of the Reserve Officers Training Corps and Selective Service on this class are also unavailable.

	B.S.	M.S.	Ph.D
Aeronautical	606	199	43
Agricultural	264	47	7
Architectural	381	12	0
Ceramic	113	34	16
Chemical	1,988	445	133
Civil	3,597	558	43
Electrical	4,076	960	111
Engineering Mechanics	6	44	25
Engineering Physics	219	74	18
General Engineering	503	62	8
Geological	186	9	2
Industrial	1,103	367	6
Mechanical	4,827	698	72
Metallurgical	486	136	53
Mining	231	22	3
Naval Architecture and Marine	46	20	0
Petroleum	460	59	6
Sanitary	13	60	6
Textile	82	11	0
Unclassified	22	69	0
Other	498	145	38
Totals	19,707	4,031	590

Allentown Division Holds Meeting

Approximately 125 members of the Allentown Division of the Lehigh Valley Section heard P. L. Bellaschi (left) discuss the development and trends for power transmission at the higher voltages last January 21. Mr. Bellaschi is a consulting engineer. Talking with Mr. Bellaschi are (center) H. J. West, Allentown Division Manager and J. C. Gray, Assistant Division Manager

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Industry Division

Committee on Industrial Control (*H. L. Palmer, Chairman; L. H. Matthias, Vice-Chairman; J. W. Picking, Secretary*). One of the two technical sessions held at the Winter General Meeting dealt with the automatic control of machines. (The other covered a variety of control subjects.) In the machine-control session one of the papers on the use of computers in the design of control systems had considerable discussion. From this discussion, it was evident that more papers of this character might be the means of closing the gap now existing between the Industrial Control Committee and the Committee on Feedback and Control Systems. This will be considered in organizing future technical sessions.

A paper on safety considerations in the design of control systems also had considerable discussion. The trend of this pointed out the need for further material on this subject. It was decided at the meeting of the Industrial Control Committee to devote a complete session to the subject of safety, as related to the design and application of control, at the Fall General Meeting in Chicago.

The Subcommittee on Test Codes is still working for agreement on test methods. A full-day meeting was held in February and Subcommittee members hope to have a proposal for full committee action this spring.

The electronic motor control working group of the Electronic Control Subcommittee is making progress in establishing definitions and test methods. It is hoped that this work can be completed during the coming year and reported at the winter meeting in 1956.

This Committee still has the problem of getting active participation by the users of control.

Committee on Chemical, Electrochemical and Electrothermal Applications (*F. S. Glaza, Chairman; R. M. Wainwright, Vice-Chairman; C. R. Olson, Secretary*). At a committee meeting held in Chicago during the Fall General Meeting, it was voted to change the committee name to "Committee on Chemical Industry." At the same time the Chemical Industry Subcommittee will change its name to the "Chemical Processes Subcommittee." The need for this change has been under discussion for some years.

To expand membership and add interest for members associated with the chemical industry on the Pacific Coast, the Pacific Coast Subcommittee was formed with F. J. Mollerus as chairman. It will include members from Districts 8 and 9. Organization is proceeding and two technical sessions are planned for the Pacific General Meeting to be held at Butte, Mont., in August.

The Committee's activities at the 1955 Winter Meeting were well attended. Three technical sessions were sponsored by the Subcommittees on Chemical Industry, Cathodic Protection, and Electrochemical Processes. Each of these subcommittees also held a business meeting. The main committee meeting on February 1, set a schedule of three technical sessions for the Summer General Meeting and two sessions for the Fall General Meeting, with a business meeting of the committee to be held at both sessions.

Committee on Electric Welding (*E. J. Limpel, Chairman; J. F. Deffenbaugh, Vice-Chairman; R. J. Krieger, Secretary*). Plans are being made for the Fifth Welding Conference which is scheduled for 1956. The American Welding Society has been requested to consider making this a joint affair with their annual spring meeting. The members of the Welding Committee feel that this would be advantageous to both societies.

The Subcommittee on Instrumentation for Resistance Welding is completing the basic work in defining requirements for instruments and measurements for resistance welding. A desirable form of final report is being considered.

Science and Electronics Division

Committee on Magnetic Amplifiers (*W. J. Dornhoefer, Chairman; H. W. Lord, Vice-Chairman; A. B. Haines, Secretary*). This committee met during the 1955 Winter General Meeting in New York City.

The Subcommittee on Magnetic Amplifier Theory had met with several of the specialists in the field of magnetism. The purpose of this was to review the most up-to-date concepts of the magnetization process. Members of the Subcommittee plan to direct efforts toward a more precise analysis of the influence of core properties upon the performance characteristics of magnetic amplifier circuits.

The two Magnetic Amplifier Sessions at the 1954 Meeting of National Electronics Conference were sponsored by the Subcommittee on Applications.

The Subcommittee on Definitions will soon circulate a revised list of proposed definitions

San Diego Past Chairmen Meet

THE PAST CHAIRMEN's Night Meeting of the AIEE San Diego Section was held on January 18, 1955. Shown above, left to right, are: G. E. Jenner, past chairman, 1947–48; H. A. Cordes, past chairman, 1948–49; J. F. Sinnott, past chairman, 1949–50; G. C. Tenney, Vice-President, District 8; J. P. Conner, past chairman, 1950–51; C. J. Nevitt, past chairman, 1941–42; Willis Kenline, past chairman, 1944–45; A. H. Keith, past chairman, 1952–53; I. E. McDougal, past chairman, 1953–54

West Michigan Section Receives AIEE Charter

AN AIEE CHARTER was presented by Institute Vice-President C. M. Summers to the new West Michigan Section January 13. Section Chairman L. A. Zahorsky (right) receives the charter

NEW OFFICERS of the West Michigan Section are (left to right): M. C. Hoover, secretary-treasurer; L. A. Zahorsky, chairman; (Vice-President Summers) and W. K. Stubbs, vice-chairman. A "presentation dinner" was held and Mr. Summers discussed AIEE objectives

of magnetic amplifier terms among members of the Magnetic Amplifier Committee and of the West Coast Subcommittee. It is hoped that the Magnetic Amplifier Committee can consider their adoption at the next meeting of the committee.

The Subcommittee on Materials proposed that the committee adopt recommended procedure for measuring the dynamic hysteresis loops as a part of a standard for testing core materials for magnetic amplifier applications. The recommendation was accepted by a unanimous vote of those members present. Three Working Groups of this Subcommittee are actively working on: additional recommended procedures for core materials evaluation, core matching and grading, and standardized core sizes.

Power Division

Committee on Transmission and Distribution (*F. V. Smith, Chairman; T. J. Brosnan, Vice-Chairman; J. T. Lusignan, Jr., Secretary*). The Committee on Transmission and Distribution met during the Winter Meeting and reviewed the work of its Subcommittees.

The Capacitor Subcommittee is proceeding with a number of studies that are expected to result in papers for the Fall Meeting. These include an addition to the Capacitor Bibliography covering material published from 1953–54 and a comprehensive report on the operation of switched capacitors.

The Distribution Subcommittee is continuing its activity in the field of higher secondary voltages, stimulated by the symposium held at the Fall Meeting.

The General Systems Subcommittee has launched an extensive investigation in conjunction with a number of other committees on the characteristics of switching surges on transmission lines. Information on the matter was requested by the Transformer Committee in order to analyze the effect of such surges on transformer installations.

First part of the study is the assembly of information on the surges resulting from switching open ended lines. While much work has been done on this matter in the past, there is not as much concrete data available as might be expected. Other studies by this Subcommittee are proceeding on arc deionization times. These are involved in high speed reclosing, fault location methods, and problems associated with fault damage due to overhead conductors, resulting from the heavy short circuits that are now obtainable on large systems.

The Lightning and Insulator Subcommittee is continuing its work on the impulse characteristics of insulators, wood, and air in series, on the establishment of a fundamental basis of insulation of transmission lines, and on the use of silicones on insulator surfaces in contaminated areas. It has also begun a new project on radio and telephone interference of transmission lines and is asking for co-operation from other committees interested in this problem.

The Towers, Poles, and Conductors Subcommittee is preparing an analysis on modern transmission line design factors for wood and steel lines, particularly as they apply to the strength of the structures, broken wire assumptions, clearances, etc.

Two AIEE Sections Celebrate Golden Anniversaries

Maryland Section

MARYLAND SECTION'S PAST CHAIRMEN (above) were honored at the Section's 50th Anniversary Celebration, January 22. Past chairman badges and certificates were presented after a social hour and dinner and prior to a dance. Left to right: (seated) G. R. Page (1941–42), C. W. Watchorn (1953–54), W. B. Kouwenhoven (1922–31), B. Van Ness, Jr. (1944–45), H. J. Casey (1942–43), J. L. Hildebrandt (1945–46). (Middle row) L. S. Billau (1937–38), L. G. Smith (1933–34), F. O. Schnure (1935–36), G. S. Diehl (1938–39), R. L. Thomas (1936–37), E. Hansson (1947–48), J. W. Magee (1951–52), F. H. Rogers (1949–50). (Back row) F. Hamburger, Jr. (1952–53), C. S. Fiske (1940–41), R. L. McCoy (1948–49), P. L. Betz (1954–55), J. W. Gore (1950–51), H. A. Frey (1939–40)

Seattle Section

PAST CHAIRMEN OF SEATTLE SECTION were honored guests at the Section's 50th Anniversary Meeting recently. Front row to back (l to r): Walter Gordon, Charles Cutter, Roy Kistler, George Hoard, Ray Rader, Edgar Loew, Kendall Howe, Joseph Hellenthal, Harold Brown, Lloyd Robinson, Charles Howe, Leo Snow, Herbert Strandberg, (back row) Christian Hawkes, Laurel Lewis, Reinier Beeuwkes, George Quinan, Austin Eastman, John Nelson. (Present but not in photograph were Magnus Crawford and Herman Gustafson). Unable to attend the meeting were: Sherwood Lindsay, James Growdon, Charles Terrell, Charles Wallis, Alvin Darland, Clarence Rogers, Gordon Shuck

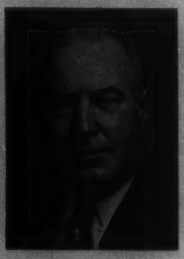
AIEE FELLOWS ELECTED..

Board of Directors Meeting, February 3, 1955

John W. Bennett (AM '26, M '29), chief engineer, Western Massachusetts Electric Company, Springfield, Mass., has been transferred to the grade of Fellow in AIEE "for his contributions to the design and construction of electric distribution and generating systems." Mr. Bennett was born in Marysville, Minn., October 17, 1897, and is a graduate of the University of Minnesota. From 1919–24 he did miscellaneous work for a number of employers including installation of private lighting plants in theaters, hotels, residences, supervision of commercial and industrial wiring installations, planning and supervising installation of electrically driven pumping machinery. He joined the Central Hudson Gas and Electric Company in 1924 as commercial engineer doing preliminary plans and estimates for electric line extensions, appraisals of property, and tests on electrical and steam apparatus. From 1925–30 he was distribution engineer for the Eastern New Jersey Power Company, now a part of Jersey Central Power and Light Company. He was head of the engineering department of this company in charge of both electrical and structural design of overhead and underground transmission and distribution lines. He supervised development of standards of distribution construction and designed substation structures and buildings. From 1930–37 he did engineering underground distribution work for western Massachusetts companies. He designed distribution systems, designed and supervised construction of subsurface structures, including transformer vaults and manholes. He also did electrical design of distribution systems and electrical equipment. During this period he made necessary economic electrical and structural studies for a low-voltage a-c network in the city of Springfield, supervising the installation of the first part of this network. He conducted research on low-voltage network cables, resulting in major redesigns by various manufacturers in their standard lines for this type of cable. He became assistant chief engineer for the Western Massachusetts Electric Company in 1937 where he had general supervision and responsibility for engineering work of all types under the general direction of the chief engineer. During the chief engineer's absence he was responsible for all engineering work. In 1944 he became chief engineer and designed the new West Springfield Steam Generating Station. Mr. Bennett is also a Fellow in the American Association for The Advancement of Science.

A. Percival Fugill (AM '24, M '30), chief electrical engineer, planning and project engineering department, The Detroit Edison Company, Detroit, Mich., has been transferred to the grade of Fellow in the AIEE "for contributions to over-all planning and design of a large utility system, development of metalclad equipment, control of noise, and application of computing devices." Mr. Fugill was born in Auburn, N. Y., March 22, 1900. He attended Syracuse University where he obtained the electrical engineer degree in 1922. From 1922–23 he was enrolled in the Westinghouse Electric and Manufacturing Company's graduate student course, and from 1923–28 was in the general engineering department of Westinghouse. He did analytical studies, application engineering, and was liaison engineer with the lower Michigan district. From 1928 to 1945 he was doing station design, system studies, and system development for The Detroit Edison Company's Engineering Division, and became bulk power system engineer in the Electrical Engineering Division of that company, 1945–49; system and stations engineer in this same division, 1949–52; and assistant chief electrical engineer in the division from 1952–54. In 1954 he became chief electrical engineer of the planning and project engineering department, his present position. The Detroit Edison system has grown from a load of about 1/2-million kw to more than 2-million kw during the past 20 years, in which Mr. Fugill has had charge of the studies and general planning of the bulk power system. In the Detroit metropolitan area this system has developed from one of 24,000-volt transmission from the power plants to the loads and main distribution centers to one of 120,000-volt cable transmission, with many additional major centers. The development of the general pattern for this system, and also of detailed elements of it, have been very largely influenced by Mr. Fugill's recommendations. He has also been active in the general problem of transformer noise and development of less noisy equipment. He was a pioneer in forming adequate test codes for noise measurement, reasonable specifications for noise in equipment, and methods of minimizing noise in substation installations. He had charge of Detroit Edison's unique system analogue and network analyzer using 60-cycle power and having other novel features, as the exact simulation of the existing power system in the analogue portion. He is the author of many technical papers on system design, noise problems, and other subjects. Many of these have appeared in *Electrical Engineering* and AIEE *Transactions*. He is also a member of the Acoustical Society of America. Mr. Fugill has served on the System Engineering Committee (1948–55).

Robert B. Gear (AM '30, M '37), director of purchases, Commonwealth Edison Company, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE "for contributions to the development of power generation and distribution in a large metropolitan area." Mr. Gear was born in Chicago, October 16, 1904. He was graduated from Cornell University in 1928 with a bachelor of science degree in electrical engineering. Immediately after graduation, he was employed by Commonwealth Edison Company, progressing within the engineering department through responsible engineering grades embodying phases of distribution and station installation work. He became a specialist in 4,000-volt transformer design and installation supervision for both underground and industrial applications. From 1933–34 he developed an underground network vault design which has remained essentially the same to date. As a field engineer from 1936 to 1941, assigned to generating station work, he co-ordinated construction and design for exact requirements to fit large quantities of 12-kv metalclad switchgear. He entered the U.S. Army in 1941 and was responsible for engineering and logistical operations. For this work he was awarded an Army Commendation Medal and the Legion of Merit. He was released from active duty in 1945, retaining the rank of Colonel, Corps of Engineers. He returned to Commonwealth Edison as senior engineer, Station Design Division. In this capacity he worked on design changes for several generating stations. In 1950 he was promoted to section engineer and placed in charge of electrical design for all generating and distributing stations. In addition to his other duties, in 1951 he was assigned to developing nuclear power for industrial purposes. He became project manager supervising the development of



J. W. Bennett

A. P. Fugill

R. B. Gear

R. C. Gorham

A. J. Hornfeck

E. L. Michelson

T. A. Taylor

nuclear power plant design in 1952. Findings from this study were ultimately published in classified documents for the Atomic Energy Commission. In 1953 he was assigned to his present position in responsible charge of purchasing all mechanical equipment, including turbogenerators, steam generators, station and substation construction, and services of all types. Mr. Gear has been active in AIEE's Chicago Section, and is at present director, Illinois Engineering Council.

Robert C. Gorham (AM '24, M '31), professor of electrical engineering, University of Pittsburgh, Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE "for diversified developmental work as an adjunct to electrical engineering education." Mr. Gorham was born in Smith County, Kansas, April 11, 1893, and was graduated from Nebraska Wesleyan University with a bachelor of arts degree in 1917. He also obtained an electrical engineering degree from Cornell University in 1924, and a master of science degree from the University of Pittsburgh in 1941. During his junior and senior years at Nebraska Wesleyan, Prof. Gorham served as laboratory assistant in the physics department. During this time he also qualified for a license as wireless station operator. He joined Westinghouse Electric and Manufacturing Company as electrical tester in 1917 at East Pittsburgh. That same year, during World War I, he entered the U. S. Navy and was a regular electrician. In the Navy, he became 1st class electrician on the *U.S.S. Northern Pacific*, in charge of all electric motors aboard ship. From 1920–21 he was at the University of Oklahoma (Norman) as physics assistant; from 1921 to 1924 he was at Cornell University, Ithaca, N. Y., as electrical engineering instructor. During 1923 he was employed in the Westinghouse electric synchronous machine design section for the summer months. In 1924–25 he was with United Electric Light and Power Company, New York, N. Y., doing special engineering tests. This included acceptance tests on new equipment; pioneering work covering measurements with the new Klydonograph of lightning surges; development of a variable d-c volt test set for underground cable testing; and the investigation of temperature and humidity conditions in substations to determine the effects of living conditions on the personnel who worked in these substations. He joined the University of Pittsburgh faculty in 1925. For 2 years as instructor he was in charge of teaching students not enrolled in electrical courses about d-c and a-c machines, and communication to electrical engineering seniors. For 8 years he was assistant professor in complete charge of lectures and the electrical engineering laboratory for electrical seniors on a-c machinery. He was associate professor for 13 years in charge of pioneering and teaching a new course to electrical seniors on the subject of engineering economics, in addition to the a-c machinery course to seniors. From 1948 to date he has been professor of electrical engineering in charge of teaching electrical engineering seniors power economics and a-c machinery. During this time he also made studies of fuses, breakers, and current relay settings for the electrical power installation at the greater Pittsburgh Airport. He is author of "Power Economics for Engineering Students," a textbook. He recently wrote a discussion for an AIEE *Transactions* paper, "Equations Depicting the Operation of the D-C Motor" by R. W. Ahlquist. He has served the Institute as District 2 representative on the National Nominating Committee (1944). He is also a member of the Pennsylvania Society for Professional Engineers, the American Society for Engineering Education, and the National Society of Professional Engineers. His name appears in "American Men of Science," "Who's Who in Education," and since 1941 in "Who's Who in Engineering." He also recently furnished information for "Who's Who in America," and is a member of the Pennsylvania State Board of Engineering Examiners. He is the recipient of many honors from various honor fraternities. Mr. Gorham has been working with the Student Branches Committee (1954–55).

Anthony J. Hornfeck (AM '37, M '43), director of research laboratory, Bailey Meter Company, Cleveland, Ohio, has been transferred to the grade of Fellow in AIEE "for contributions to telemetering and to instrumentation for process and generating station control." Mr. Hornfeck was born in Homestead, Pa., September 12, 1912. He graduated from the University of Pittsburgh with a bachelor of science degree in electrical engineering with high honors in 1935. From 1935–36 he was student engineer on test, General Electric Company, Schenectady, N. Y.; 1936–38 he was in the engineering general department of the company. He joined the Bailey Meter Company in 1938 as research engineer and remained in that position for 10 years. In 1948 he became supervisor of electrical research for the company, and in 1953 director of the company's research laboratory, his present position. In this position he has major responsibility for the development of all electric and electronic instruments including sensing elements, servo-actuated null-balance recorders, telemetering and control systems. Some of his primary contributions include: development and application of electronic servo-amplifiers to instrumentation and control; design of saturable reactor devices for motor control and d-c to a-c conversion; development of measuring elements for temperature, pressure, flow, smoke density, and other process variables; development of circuits for the use of the differential transformer for the measurement and transmission of displacement; application of analogue computer techniques to the measurement and control of derived process variables; and application of electric circuit analysis to the study of response and simulation of physical systems. He holds about 50 patents and is the author of a number of technical papers. His other memberships include the Instrument Society of America and the American Association for Advancement of Science. Mr. Hornfeck has been working with the Instruments and Measurements Committee (1949–55).

Ernest L. Michelson (AM '37, M '44), assistant system planning engineer, Commonwealth Edison Company, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE "for his contributions to power system engineering." He was born March 10, 1908, at St. John, New Brunswick, Canada, and graduated from the Illinois Institute of Technology in 1929 with a bachelor of science degree in electrical engineering. After graduation he joined Commonwealth Edison as a student engineer and upon completion of the company course, was assigned to the system planning activities of the engineering department. He advanced through various engineering grades and in 1952 was appointed assistant system planning engineer of the newly created system planning department. In the absence of the system planning engineer, Mr. Michelson is in charge of the enlarged system planning department which resulted from a consolidation of planning activities of the Public Service Company of Northern Illinois and of Commonwealth Edison Company. During these years at Commonwealth, Mr. Michelson has had a wide scope of activities connected with the design of the high-voltage system, but also including much detailed work on components of the system, such as the design and application of protective relaying, the design of bus layouts, and general consideration of stability problems, short circuits, and similar technical problems. He is a member of the Western Society of Engineers. He is the author of eight AIEE papers and has served on the following committees: Relays (1947, 1949–51, chairman 1949–51); Standards (1949–50); Technical Program (1949–50); Power Co-ordinating (1949–53); System Engineering (1951–55); Sections (1951–53).

Thomas A. Taylor (AM '30, M '36), chief engineer, The Pacific Telephone and Telegraph Company, San Francisco, Calif., has been transferred to the grade of Fellow in AIEE "for leadership in solution of inductive co-ordination problems and in the field of communications engineering." Mr. Taylor was born November 9, 1906, in Brooklyn, N. Y. He graduated June, 1928, obtaining

a bachelor's degree in electrical engineering, magna cum laude, from Harvard Engineering School, Cambridge, Mass. He was with the American Telephone and Telegraph Company, New York, from 1928–34. He did laboratory, field, and office work on inductive co-ordination of power and telephone systems at voice frequency, with particular emphasis on studies of power system wave shape and application of wave shape corrective devices. He was in charge of various field tests concerned with inductive co-ordination problems and preparation of reports covering results. From 1934–39 he was engineer on inductive interference for Bell Telephone Laboratories, New York, N. Y. He was responsible for several field investigations and in active charge of joint investigation of inductive influence of rural distribution circuits under general direction of the Board of Railway Commissioners of the State of Iowa during the summer of 1935. He was engineer in charge of noise and low-frequency induction activities for Bell System Companies, consulting engineer for companies in connection with problems of power system co-ordination. Mr. Taylor was engineer in charge of noise and low-frequency induction activities for Bell System Companies–American Telephone and Telegraph Company from 1939 to 1946. He did field investigations in all parts of the United States preparing engineering recommendations and reports. Later he was in charge of exchange transmission engineering, including extension of rural telephone service by power line carrier and other new facilities—preparation of Bell System practices relating to exchange transmission and recommendations regarding rural plant extension. From 1946–49 he was group head of electrical co-ordination, American Telephone and Telegraph Company; from 1949–50 group head of the construction program; in 1950, plant extension engineer. He became assistant vice-president of The Pacific Telephone and Telegraph Company in 1950 and from 1953 to date has been chief engineer of the Northern California and Nevada area of the company. Mr. Taylor has served on the following committees: Automatic Stations (1945–46); Electronic Power Converters (1947, 1949).

AIEE PERSONALITIES.....

M. D. Hooven Nominated for Institute President

Morris D. Hooven (AM '24, M '30, F '44), electrical engineer, electrical engineering department, Public Service Electric and Gas Company, Newark, N. J., has been nominated as the 1955–56 President of AIEE. He was born on May 30, 1897, in Weatherly, Pa., and was graduated from Bucknell University magna cum laude in 1920. After a year in the employ of the Westinghouse Electric Corporation, he became manager of the radio department of the Robbins Electric Company, Pittsburgh, Pa. He became associated with the Public Service Electric Company in 1922 as one of a group engaged in the planning and design of the 132-kv system. He handled assignments in transmission and substation work, receiving the title of assistant transmission and substation engineer in 1939. Since 1942 he has held the position of electrical engineer in the electrical engineering department. Mr. Hooven is a member of the Institute of Radio Engineers and the National Society of Professional Engineers. He has served as Vice-President, District 3, of the Institute (1952–54), Director (1948–52), and on the following committees: Technical Program (1942–47, chairman 1945–47, 1949–50); Board of Directors (1948–52); Planning and Co-ordination (1945–47, chairman, 1949–55); Institute Publicity (1945–47); Engineers' Council for Professional Development (1948–55); Award of Institute Prizes (chairman, 1945–47); Special Committee to Review Practices in Award of Institute Prizes (1946–47); Board of Examiners (1948–49); Edison Medal (1948–1952); Finance (1950–54); Technical Operations (1952–55); Executive (1952–54); Publication (chairman 1953–55), Public Relations (1953–55); Engineers Joint Council (1954–55).

Vice-Presidential Nominees Are Ballard, Cozzens, Jones, Miller, and Pearce

Bristow Guy Ballard (AM '33, M '44), director, Radio and Electrical Engineering Division, National Research Council of Canada, Ottawa, Ont., Can., has been nominated to serve on the AIEE Board of Directors. Mr. Ballard was born in Fort Stewart, Ontario. He graduated from Queen's University, Kingston, Ont., in electrical engineering in 1924 and entered a graduate course offered by Westinghouse Electrical and Manufacturing Company at East Pittsburgh, Pa., subsequently entering the engineering department of that company. He was engaged by the National Research Council of Canada in 1930 in charge of electrical engineering research. In 1948 he was appointed director of the Division of Radio and Electrical Engineering, and in 1954 vice-president (scientific) of the Council. During World War II, Mr. Ballard's activities were largely devoted to the development of mine sweepers for enemy magnetic mines and the protection of ships against these mines. In recognition of his contributions in this field, he was awarded the Order of the British Empire in 1946. He is past president of the Canadian Committee of the International Electrotechnical Commission, member of the board of directors and chairman of the Approvals Administrative Board of the Canadian Standards Association, and a Fellow of the Institute of Radio Engineers. He has served on the Research Committee (1946–55); and as liaison representative on the Standards Comittee (1953–55).

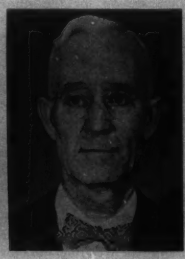
Bradley Cozzens (AM '28, M '38, F '48), assistant chief electrical engineer of the Department of Water and Power, City of Los Angeles, Calif., has been nominated to serve the Institute as Vice-President of the Pacific District (Number 8). Mr. Cozzens was born in San Jose, Calif., November 20, 1903. In 1925 he received his bachelor of arts degree in mathematics from the College of the Pacific and completed graduate study with the degree of electrical engineer from Stanford University in June, 1927. He was immediately employed with the Department of Water and Power as a junior electrical engineer. During the following nine years he carried on studies and laboratory research at the Harris J. Ryan High Voltage Laboratory and laboratories of Eastern manufacturers in connection with the calibration of high voltage testing equipment, measurements of corona loss, impulse voltage testing equipment, measurements of corona loss, impulse voltage testing, and arc and insulation phenomena. In 1940 he was assigned head of the research and statistical section, responsible for economic planning, and load forecasting, and was a member of the System Planning Committee. In 1946 he became engineer in charge of communication and transmission line operation, and in 1948 as executive assistant to the general manager. He succeeded to his current position in April, 1951. He has served as a member of the Los Angeles Engineering Council representing the AIEE and also on

M. D. Hooven

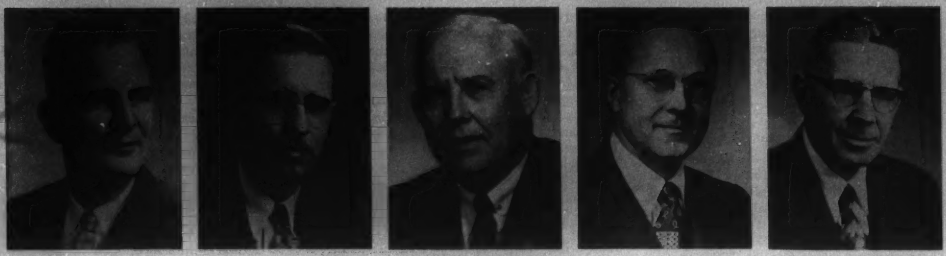
B. G. Ballard

B. Cozzens

E. R. Jones



W. J. Miller



C. T. Pearce J. D. Tebo P. G. Wallace J. C. Woods W. J. Barrett

the following Institute committees: Sections (1949–55) and Planning and Co-ordination (1954–55).

Evan R. Jones (AM '25, M '31), toll-circuit layout supervisor, Mountain States Telephone and Telegraph Company, Denver, Colo., has been nominated to serve the Institute as Vice-President representing the North Central District (Number 6). He was born February 5, 1902, in Anaconda, Teller County, Colo., and received his bachelor of science degree in electrical engineering from the University of Colorado in 1923. In 1924 he received his master of science degree, and in 1928, the degree of electrical engineer, both from the University of Colorado. From 1923–28 Mr. Jones served on the faculty of the Department of Physics at the University of Colorado. He joined the Mountain States Telephone and Telegraph Company in 1928, in the general engineering department. He has served that company as an equipment engineer, transmission engineer, and as toll circuit layout supervisor. Mr. Jones was elected to Tau Beta Pi in 1922, was a charter member of Colorado-Wyoming Academy of Science, and is a member of the Colorado Engineering Council. Mr. Jones has served on the Wire Communications Systems Committee (1951–55).

William Jasper Miller (AM '19, M '26, F '43), professor and head of the electrical engineering department, University of Alabama, University, Ala., has been nominated to serve the Institute as Vice-President representing the Southern District (Number 4). Mr. Miller was born in December 12, 1893, in Skidmore, Tex. He graduated from the University of Texas in 1915 with the degree of electrical engineer and also obtained the master of science degree from Massachusetts Institute of Technology (MIT) in 1922. After graduation in 1915, Mr. Miller joined Southwestern Telephone and Telegraph Company. He was next employed in General Electric Company's testing department at Schenectady, N. Y. and at Pittsfield, Mass. In 1917, he was appointed instructor of electrical engineering at the University of Texas (Austin). After 2 years he was advanced to adjunct professor and from 1920–21 he served as instructor of electrical engineering, while doing graduate work at MIT. He was head of the electrical engineering department at Oklahoma Agricultural and Mechanical College (Stillwater) from 1921–23 and from 1923–25 established and directed the engineering experiment station at the University of Arkansas. He was appointed the first dean of engineering in 1925 at Texas Technological College which began operations that year in Lubbock, Tex. In 1932 he joined the faculty of the University of North Carolina at Chapel Hill as professor and head of the electrical engineering department. He also served as acting dean of engineering during 1933–36. When engineering at Chapel Hill was merged with the Raleigh Division in 1936, he accepted appointment as professor and head of the department of electrical engineering at the University of Alabama in Tuscaloosa. He has served the following AIEE committees: Membership (1945–46), Education (1938–41), Student Branches (1941–42). He served as Student Branch Counselor, Texas Technological College Branch (1930–31), University of North Carolina Branch (1932–35), University of Alabama Branch (1939–42, 1946–48). He was also AIEE representative on the Engineers Council for Professional Development Committee for Accrediting of Engineering Colleges in District 4 (1938–52), and District chairman.

Cullen Thomas Pearce (AM '36, M '40, F '49), Middle Atlantic engineering and service manager, Westinghouse Electric Corporation, has been nominated to serve the Institute as Vice-President representing the Middle Eastern District (Number 2). Mr. Pearce was born in Texas in 1901. He graduated from the University of New Mexico in 1923, and entered the employ of the Westinghouse Electric Corporation in July of that year in the company's graduate student training course. Upon completion of this course he became associated with the design of large direct-current rotating apparatus and was employed in this field until 1927. From 1927 to 1935 he was identified with the application of marine and industrial equipment manufactured by Westinghouse. In 1935 he obtained a master's degree from the University of Pittsburgh. In that same year he was transferred to the company's Philadelphia office where he became engaged in the engineering selection and application of equipment used by industries in the Middle Atlantic area. In 1938 he was appointed Atlantic region engineering and service manager of the Westinghouse Electric Corporation, the position he now holds. He is responsible for the engineering work associated with the application of all mechanical, electrical, and electronic devices manufactured by Westinghouse and used by industries located in the Middle Atlantic States, together with the servicing, installation, and repair of this apparatus. Mr. Pearce has been active for several years in the affairs of the Philadelphia Section, a vice-chairman of the National Membership Committee (1946–48), member-at-large on National Membership Committee (1948–49), member of National Committee on Rotating Machinery (Power Division) (1952–53), and member of National Committee on Transfers (1954–55). Mr. Pearce has served on the following committees: Membership (1946–49); Rotating Machinery (1952–53); Transfers (1954–55).

Tebo, Wallace, and Woods Nominated for Directorships

J. D. Tebo (AM '36, M '36, F '51), technical editor of Bell Telephone Laboratories, New York, N. Y. has been nominated to serve on the AIEE Board of Directors. Born July 5, 1903, in Harpers Ferry, West Va., Dr. Tebo received the degrees of bachelor of engineering in 1924 and doctor of engineering in 1928 from the Johns Hopkins University. In 1924 and 1925 he took the student training course in meter and relay operating at the Westinghouse Electric Corporation, East Pittsburgh, Pa. His association with Bell Telephone Laboratories began in the summers of 1926 and 1927, continuing in 1928, at which time he was engaged in electromagnetic design, particularly as applied to co-ordination between power and telephone lines. In 1938, he was put in charge of the machine switching laboratory. During World War II, he was concerned with the development and manufacture of radar and sonar equipment for use by the Armed Forces. Following the war, he returned to machine switching and in 1949 became science editor of the Bell Laboratories *Record*. He was appointed Editor of the Bell System Technical Journal and of the Bell Laboratories *Record* in 1953. Mr. Tebo has served AIEE on the following committees: Basic Sciences (1937–55, chairman 1946–48); Communication and Science Coordinating (1947–49, chairman 1948–49); Science and Electronics Co-ordinating (1949–52, chairman 1949–50); Computing Devices (1948); Standards Committee (1946–48); Technical Program (1946–50); Award of Institute Prizes (1948–50); Planning and Co-ordination (1948–50; 1954–55); Technical Advisory (1950–52); Publication (1951–55); Sections (1951–53); Liaison Representative on Standards (1951–54); and Technical Operations (1952–55, chairman 1954–55). He is also a member of the

American Standards Association, a licensed professional engineer, a member of Sigma Xi, and the Montclair Society of Engineers.

Paul G. Wallace (AM '40, M '47), assistant chief engineer, Texas Power and Light Company, has been nominated to serve on the AIEE Board of Directors. Mr. Wallace was born in Omaha, Tex., January 15, 1903, and attended Burleson College and Texas Agricultural and Mechanical College, graduating in 1924. He joined Texas Power and Light as electrical draftsman in 1924; became drafting supervisor in 1927, design engineer in 1930 and head of the Design Division in 1939; chief electrical engineer in 1951, and assistant chief engineer in 1952. He also is a member of the Texas Society of Professional Engineers and is now state chairman of the Guidance Committee of Engineers Council for Professional Development. Mr. Wallace has been on the following AIEE committees: Registration of Engineers (1949–51); Transmission and Distribution (1950–55); and the Edison Medal Committee (1953–58).

John C. Woods (AM '23, M '31, F '53), system station electrical engineer, Commonwealth Edison Company, Chicago, Ill., has been nominated to serve on the AIEE Board of Directors. Mr. Woods was born on October 26, 1896, at Grayson, Ky., and attended the Westinghouse Technical School and Armour Institute of Technology. He joined Commonwealth Edison Company in 1922 as a draftsman and advanced through a succession of engineering positions in the electrical engineering department to his present position of system station electrical engineer—heading the department, having jurisdiction over the electrical design of generating stations, substations, and distribution centers for the Commonwealth Edison system. Mr. Wood's AIEE committee memberships include: National Membership Committee (1946–53, chairman, 1950–53); member, Subcommittee on Switches, Fuses, and Insulators (1945–present); Correlation of Standard Temperature Rises (1948–52); Rating Factors for Instrument Transformers (1948–50); Network Protectors (Chairman, 1951–53); Committee on Switchgear (1947–present, vice-chairman, 1954–present); National Nominating Committee (1951–52); vice-chairman, General Committee AIEE Participation in Centennial of Engineering (1952).

W. J. Barrett Renominated as Institute Treasurer

Walter J. Barrett (M '36, F '50), electrical co-ordination engineer, New Jersey Bell Telephone Company, Newark, N. J., has been renominated to serve the AIEE as Treasurer. Mr. Barrett was born in Brooklyn, N. Y., January 10, 1899, and was graduated from the Polytechnic Institute of Brooklyn in 1920 with the degree of electrical engineer. Upon graduation, he entered the employ of the American Telephone and Telegraph Company, New York, N. Y., and in 1924 was transferred to the staff of the transmission engineer for the company. In 1930 Mr. Barrett became a supervisor in the engineering department, New Jersey Bell Telephone Company, Newark, and worked in that capacity until his appointment as electrical co-ordination engineer in 1943. Mr. Barrett has been serving as Institute Treasurer since 1953, and has served also as a Director (1949–52), District 3 secretary (1948–49), New York Section secretary and chairman, and on many AIEE committees. Formerly vice-president and chairman of the finance committee of United Engineering Trustees, he is now president. He is also a director of Engineers Joint Council. Mr. Barrett has served on the following Institute committees: Sections (1948–50); Finance (1949–52, chairman 1950–52); Board of Directors (1949–50, 1954–55); Communication Division (1950–53); Lamme Medal (1950, 1953); Planning and Co-ordination (1950–55); Headquarters (1950–53); Executive (1950–55); Joint AIEE-IRE Co-ordination Committee (1951–53, chairman 1953–55); Board of Trustees, United Engineering Trustees, 1951–1955); Board of Examiners (1952–53); Engineers Joint Council, representative (1954–55).

C. S. Purnell (AM '29, M '35), sales executive for the Westinghouse Electric Corporation at New York, N. Y., for many years, has been named manager of the company's South Pacific district, headquartered in Los Angeles, Calif. Mr. Purnell is a member of AIEE's Board of Directors and is a past vice-president of the Institute. He also holds membership in the Engineers Club and the Downtown Athletic Club, New York, N. Y. A native of Frostburg, Md., Mr. Purnell joined Westinghouse as a graduate student at East Pittsburgh, Pa., in 1922, soon after receiving his bachelor of science degree from Washington College, Chestertown, Md. He was transferred to the company's New York office in 1927 as an application engineer for the Transportation Division and later assigned to a similar post with the Industrial Division. Since mid-1952, and until his new assignment, he has served as manager of the electrical utility department for the Northeastern region, headquartered at New York, N. Y. Mr. Purnell has served on the following Institute committees: Sections (1943, 1950–55, chairman 1951–53); Headquarters 1948, 1950, chairman 1948 and 1950, 1953–54); Edison Medal (1950, 1952, 1954); Finance (1950–55, chairman 1953–55); Board of Directors (Vice-President District 3, 1950 and 1952); Executive (1951–55); Planning and Co-ordination (1952–55), and Engineers Joint Council representative (1954–55).

William Dubilier (AM '19, M '19, F '25), founder of the Cornell-Dubilier Electric Corporation, has received the first annual award of the Gano Dunn Medal. Established this year, the medal will be awarded annually to an alumnus of Cooper Union for outstanding professional achievement. Mr. Dubilier is being honored for his inventions and development of high-voltage condensers, or capacitors. He was born in New York, N. Y., in 1888 and attended public schools there. He became interested in wireless while attending lectures by Marconi and shortly afterward became his assistant. He studied at Cooper Union College in New York, N. Y., and simultaneously worked at night for the American Telephone and Telegraph Company. In 1909 he was invited by Standard Oil Company to Seattle, Wash., to construct a broadcasting station for communication with Alaska. He also built a radio station in the Czar's Palace in St. Petersburg. In 1910 he began his experiments to improve the Leyden jar. This led to his invention of the capacitor. The Dubilier Corporation was the sole supplier of condensers for the U. S. Government during World War I. Mr. Dubilier is a fellow of the Institute of Radio Engineers and a member of the Royal Society of Arts and Sciences. He received the gold Plames Academiques, the highest scientific award of the French Government, and the Grand Medal of the Association des Ingenieurs-Docteurs de France. His name also appears in "Who's Who."

A. E. Knowlton (M '17, F '30), senior associate editor, *Electrical World*, has retired. He has been named consulting editor and will continue to advise the engineering staff. Mr. Knowlton was born in New Haven, Conn., and received his bachelor's degree in electrical engineering from Trinity College in 1910. He obtained his master of science degree in 1912 and the electrical engineering degree from Yale in 1921. He also studied at Columbia University. Before joining *Electrical World* in 1930 as associate editor, he had been on the Yale faculty. He had also taught mathematics and physics at Trinity College. When he left Yale, he was an associate professor. Mr. Knowlton's other technical memberships include The American Society of Mechanical Engineers

C. S. Purnell

W. Dubilier

and the National Association of Corrosion Engineers. He has been active on local AIEE committees and has served on the following national AIEE Committees: Instruments and Measurements (1924, 1927, chairman 1924 and 1927, 1943–46, 1948–51); Meetings and Papers (1924, 1931, chairman 1929 and 1931); Publication (1929 and 1931); Co-ordination of Institute Activities (1929, 1931); Award of Institute Prizes (1929, 1932, chairman 1929 and 1931, 1950–51); Edison Medal (1930, 1934, 1943–44, 1949); Popular Science Award (1930 and 1931, chairman 1930–1932); Alfred Noble Prize Committee (1930 and 1932); Transportation (1932–33); General Power Applications (1932, 1943–45); Industrial Power Applications (1932, 1943–45); Electrochemistry and Electrometallurgy (1933, 1936); Economic Status of the Engineer (1933–34); Safety Codes (1933–34); Board of Examiners (1937, 1943, chairman 1940 and 1943, 1944–46, 1948–55); Transfers (1944–47); Publicity and Public Relations (1945–46, 1948–55); Professional Group Co-ordination (1948–1949); Power Co-ordinating (1949–51); and Planning and Co-ordination (1950–54).

M. H. McGrath (AM '26, M '49), chief engineer, General Cable Corporation, has been elected a vice-president of the company. Mr. McGrath became assistant chief engineer for General Cable in 1946. From 1942–44 he served the company as representative on a special full-time 4-company committee setup by the Bureau of Ships, U. S. Navy, to develop buoyant magnetic mine-sweeping cables for use in World War II. He was presented with the "Certificate of Commendation" for services. He returned to General Cable in 1944 where he was sponsor engineer for paper and varnished cambric cable. He was responsible for making engineering recommendations on design, installation, and maintenance of paper and varnished cambric cable supplied by the company. From 1924–29 he was assistant to the development engineer for Standard Underground Cable Company, in charge of executing impregnated paper cable development work carried on in the Pittsburgh Research Laboratory of Standard Underground Cable. From 1929–39 he was assistant to the chief engineer with special assignments relating to high-voltage applications of wire or cable. He has served on the following AIEE Committees: Insulated Conductors (1951–55, chairman 1953–55), and Power Division (1953–55).

A. J. Hoehn (AM '42, M '51), Electrical Engineering Division, Armour Research Foundation, Chicago, Ill., has been named assistant manager in the electrical engineering research department at Armour Research Foundation. In addition to other duties, he will continue temporarily as acting supervisor of one of the sections. He joined the staff as associate electrical engineer in 1947, was promoted to electrical engineer in 1949, and to supervisor in 1951. He received his B. S. degree from Iowa State College and his M. S. from the University of Minnesota. He formerly was a junior engineer with the Commonwealth Edison Company, Chicago, Ill.; an instructor at Iowa State College; radio engineer with the Stromberg-Carlson Company, Rochester, N. Y.; and an instructor at the University of Minnesota. At Armour Research Foundation he has worked principally in radar systems, receivers, intermediate-frequency amplifier systems, and antennas. He is a member of the Institute of Radio Engineers, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

V. J. Nexon (AM '45), vice-president and senior consultant, Microwave Services, Inc., has been appointed president of Microwave Services, Inc., firm of communications consulting engineers. The firm specializes in surveys, studies, system designs, specifications, and construction of wire, carrier, radio, and television communication systems. Mr. Nexon has been vice-president and senior consultant of Microwave Services, Inc., since March 1952. He was formerly with Federal Telephone and Radio Corporation from 1946 to 1951 as a communications system engineer for wire, carrier, and radio transmission equipment. From 1942 to 1946 he served with the Signal Corps and Air Force as communication officer on vhf and radar installations. In the beginning of World War II, he was on special assignment with the Royal Air Force on the British Isles for vhf ground–air-borne communications systems. Prior to 1942, Mr. Nexon was with the Ohio Power Company as a commercial-industrial engineer on power application work. He was graduated from Case Institute of Technology, Cleveland, Ohio, with a B. S. in electrical engineering and is a member of Tau Beta Pi, Sigma Xi, Eta Kappa Nu, and the Institute of Radio Engineers. He has served on AIEE's Radio Communication Systems Committee (1954–55).

OBITUARY • • • •

Wilfred T. Lowery (AM '22, M '50), Toledo Edison Company staff electrical engineer, died last Thanksgiving Day after a long illness. He had been with Edison since 1916 when he enrolled in the cadet engineering program. Mr. Lowery was chief electrical engineer from 1950 to 1953 when he was appointed staff electrical engineer. He joined the company after graduation from Rensselaer Polytechnic Institute, Troy, N. Y. A native of Massachusetts, he was educated in the public schools of Richmond, Va. During World War I, he served in the Signal Corps and the field artillery. Upon his return to Toledo in 1919, he became distribution engineer and later a regulation engineer. In 1924 he was made assistant chief engineer. Mr. Lowery was past chairman of AIEE's Toledo Section.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of February 17, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Ast, P. F., laboratory engineer ,General Electric Co., Pittsfield, Mass.

Auerbach, I. L., manager, Special Products Div., Burroughs Corp., Paoli, Pa.

Batcheller, J. R., electrical engineer, Leslie E. Poole, consulting engineers, Portland, Ore.

Bennett, B. F., manager, machine tool unit, General Electric Co., Schenectady, N. Y.

Campbell, W. M., district manager, BullDog Electric Products Co., Toledo, Ohio

Chun, M. E., engineer, Halliburton Oil Well Cementing Co., Houston, Tex.

Daniels, L. H., electrical engineer, Waterways Experiment Station, Vicksburg, Miss.

Deffenbaugh, J. F., chief, electrical engineering, Federal Machine & Welder Co., Warren, Ohio

Dumas, A. M., design engineer, General Electric Co., Pittsfield, Mass.

Eliasen, A. N., electrical engineer, Sargent & Lundy, Chicago, Ill.

Esher, J. R., Jr., project & development engineer, General Electric Co., Schenectady, N.Y.

Furness, J., engineer, Sperry Gyroscope Co., Great Neck, N. Y.

Goodman, D. J., manager, electrical branch, ARO, Inc., Tullahoma, Tenn.

Guyton, M. E., senior service engineer, Federal Pacific Electric Co., San Francisco, Calif.

Hanna, W. J., asst. professor of electrical engineering, University of Colorado, Boulder, Colo.

Harvey, I. M., electrical engineer, Bethlehem Mines Corp., Johnstown, Pa.

Hudson, J. E., engineer, General Electric Co., Schenectady, N. Y.

Hughes, K. M., supervisor, transformer group, U.S.&S. Div., Westinghouse Air Brake Co., Pittsburgh, Pa.

Hutto, R. L., electrical engineer, U. S. Corps of Engineers, Nashville, Tenn.

Ishikawa, K., director & chief engineer, Tokyo Shibaura Electric Co., Kanagawa-ken, Japan

Jachym, T. M., design engineer, General Electric Co., Schenectady, N. Y.

Jackson, W. J., regional operations engineer, Hydro Electric Power Comm. of Ontario, Hamilton, Ont., Can.

Juliana, W. J., engineer, General Electric Co., Pittsfield, Mass.

MacNichol, G. F., district engineer, Southern Bell Tel. & Tel. Co., Pensacola, Fla.

Magnusson, E. F., engineering analyst, General Electric Co., Schenectady, N. Y.

Manko, R. E., engineering supervisor, General Electric Co., Schenectady, N. Y.

Marter, W. E., protection engineer, Duquesne Light Co., Pittsburgh, Pa.

McCown, W. E., senior engineer, Westinghouse Electric Corp., Pittsburgh, Pa.

Molinaro, A. D., engineer, testing div., Philadelphia Electric Co., Philadelphia, Pa.

Nardi, F. J., machine tool supervisor, General Electric Co., Schenectady, N. Y.

Salle, W. H., transmission engineer, Commonwealth Edison Co., Chicago, Ill.

Satyendra, K. N., senior engineer, Westinghouse Electric Corp, Baltimore, Md.

Smith, R. C., Jr., electrical engineer, General Electric Co., Schenectady, N. Y.

Stanfield, T. O., general foreman, General Electric Co., Pittsfield, Mass.

Thacker, H. B., distribution engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

Tucker, D. D., electrical engineer, Southwestern Public Service Co., Amarillo, Tex.

Ward, J. H., asst. division engineer, Southwestern Gas & Electric Co., Texarkana, Ark.

Webb, G. W., design engineer, General Electric Co., Pittsfield, Mass.

Wrentmore, L. L., manager, distribution apparatus sales, Westinghouse Electric Corp., East Pittsburgh, Pa.

Wynn, T. C., superintendent, elec. maintenance dept., Lower Colorado River Authority, Austin, Tex.

40 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before April 25, 1955, or June 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Decker, H. L., Pennsylvania Railroad Company, Philadelphia, Pa.

Hammond, R. E., Radio Engineering Products Ltd., Montreal, Que., Canada.

Marshall, H. E., New Brunswick Electric Power Commission, Fredericton, N. B., Canada.

Schubert, W. E., Wisconsin-Michigan Power Company Appleton, Wis.

Townley, A. N., The Sydney County Council, Sydney, N.S.W., Australia

5 to grade of Member

OF CURRENT INTEREST

New York International Airport Development to Begin This Fall

Plans for a $60 million passenger terminal development at New York International Airport, a "Terminal City" of ten terminal buildings capable of accommodating 140 aircraft at one time, were made public by Bayard F. Pope, acting chairman of The Port of New York Authority, operator of the 5,000-acre airport. An innovation in airport design, the development will comprise an 11-city-block-long International Arrival Building with two adjacent Airline Wing Buildings, seven individual airline terminal buildings, and roadways, taxiways, aprons, and related facilities, all within a 655-acre central landscaped oval. The central terminal area is 105 acres larger than all of La Guardia Airport and three-fourths as large as Central Park.

Construction of the terminal development will commence this fall and the International Arrival Building and the two Airline Wing Buildings will be completed early in 1957. The construction of the airline unit terminals will begin as soon as design plans are prepared and contracts let.

Wallace K. Harrison, internationally famous architect of Rockefeller Center, the United Nations, and many other outstanding developments, is serving as design consultant and co-ordinator of exterior architecture of the various buildings. The Port Authority buildings were designed, in collaboration with the Port Authority staff, by Skidmore, Owings and Merrill. Both in the planning and design of the terminal area and the terminal buildings, the Port Authority received the utmost assistance and co-operation from all of the airlines concerned.

This very modern and efficient air passenger terminal, as well as the largest in the world, will provide the flexibility of design and adequacy of facilities and services necessary to keep step with the growing volume of international and long-distance air travelers at the airport, expected to number more than 8½-million as early as 1965. This is the number of passengers handled in 1953 by Washington National Airport, Orly Airport (Paris), London Airport, Los Angeles International Airport, and San Francisco Airport combined.

The ten passenger terminal buildings, all facing a magnificent 160-acre plaza, will have an aggregate floor area of over a million square feet. The Arrival Building and two adjacent Wing Buildings will accommodate up to 32 plane positions; the individual airline buildings, 8 or 16 aircraft positions de-

MAIN entrance (artist's conception) to International Arrival Building, New York International Airport, showing elevated promenade and control tower

PASSENGER terminal area (artist's conception), New York International Airport

Future Meetings of Other Societies

Atomic Industrial Forum—Stanford Research Institute, Atomic Energy Meeting. April 4–5, 1955, Mark Hopkins Hotel, San Francisco, Calif.

National Fluid Power Association, 2nd Annual Meeting. April 4–6, 1955, Broadmore Hotel, Colorado Springs, Colo.

Radio Technical Commission for Aeronautics—Institute of Radio Engineers, Los Angeles Section, Spring Assembly Meeting. April 5–7, 1955, Institute of Aeronautical Science Building, Los Angeles, Calif.

The American Society of Mechanical Engineers, Machine Design Division and New York Metropolitan Section, National Machine Design Conference. April 6, 1955, New York University, University Heights Campus, New York, N. Y.

Society of Plastics Industry, Pacific Coast Section Conference. April 13–15, 1955, Palm Springs, Calif.

Northwest Electric Light and Power Association, Engineering and Operation Section, Meeting. April 13–15, 1955, Davenport Hotel, Spokane, Wash.

Polytechnic Institute of Brooklyn, Symposium on Modern Network Synthesis. April 13–15, 1955, Engineering Societies Building, New York, N. Y.

American Ordnance Association, Proving Ground Instrumentation Committee, Symposium. April 14–15, 1955, Patrick Air Force Base, Eau Galli, Fla. Security Classification: Secret.

The American Society of Mechanical Engineers, Spring Meeting. April 18–20, 1955, Lord Baltimore Hotel, Baltimore, Md.

Stanford Research Institute, Third National Air Pollution Symposium. April 18–20, 1955, Huntington-Sheraton Hotel, Pasadena, Calif.

Agricultural and Mechanical College of Texas, Eighth Annual Conference for Protective Relay Engineers. April 25–27, 1955, College Station, Tex.

Institute of Radio Engineers, Phoenix Section, Seventh Regional Conference and Trade Show. April 27–29, 1955, Hotel Westward Ho, Phoenix, Ariz.

Pennsylvania Electric Association, Meter Committee, Spring Meeting. April 28–29, 1955, Hotel Washington Duke, Durham, N. C.

Institute of Radio Engineers, Boston and Connecticut Valley Sections, New England Radio-Electronics Meeting. April 29–30, 1955, Sheraton-Plaza Hotel, Boston, Mass.

National Metal Trades Association, Western Plant Management Conference. May 1–4, 1955, French Lick Springs Hotel, French Lick, Ind.

Society of American Military Engineers, Annual Meeting. May 5–6, 1955, Hotel Waldorf-Astoria, New York, N. Y.

American Association of Spectographers, 6th Annual Conference. May 6, 1955, Engineers' Building, Chicago, Ill.

Society of Plastics Industry, Annual Meeting and Conference. May 7–15, 1955, Cruise on Queen of Bermuda.

Northwest Electric Light and Power Association, Business Development Section, Meeting. May 9–11, 1955, Hotel Utah, Salt Lake City, Utah.

Metal Power Association, National Meeting and Show. May 10–12, 1955, Bellevue-Stratford Hotel, Philadelphia, Pa.

Chicago Electrical Industry Show, Annual Show. May 10–12, 1955, Conrad Hilton Hotel, Chicago, Ill.

Pacific Coast Electrical Association, Annual Convention. May 11–13, 1955, Sheraton Palace Hotel, San Francisco, Calif.

Public Utilities Advertising Association, Annual National Convention. May 12–13, 1955, Sheraton Hotel, Chicago, Ill.

Michigan State College, Symposium on Automation. May 13, 1955, Engineering School, East Lansing, Mich.

American Materials Handling Society. National Materials Handling Exposition. May 16–20, 1955, International Amphitheater, Chicago, Ill.

pending upon the size of the unit, with a combined capacity for handling 108 planes at one time.

The 3-story International Arrival Building with a floor area of 227,500 square feet will handle all incoming international passengers requiring customs clearance, expected to number almost three-quarters of a million in 1965. The existing 11-story Control Tower will be enclosed and connected with the International Arrival Building by an elevated promenade. If the 1,250-foot-high Empire State Building were laid on its side, it would extend only a little more than half the length of this 2,200-foot-long by 660-foot-deep structure.

New York International Airport, in the short span of 6 years, has become an air crossroads of the world. This airport, a major American terminus of the important North Atlantic route, is now used regularly by 24 of the airlines, international and domestic, including cargo and helicopter operators. By 1960 it is expected that the airport will give jobs to 16,500 people at an annual payroll of $82 million; by 1965, 18,500 people will earn $100 million or almost double the current payroll.

Assembly Machine Designed for Production of Printed Circuits

The first automatic assembly machine for attaching diverse electronic components to printed circuits has been developed and sold by the Mechanical Division of General Mills, Inc., to International Business Machines Corporation (IBM).

The machine, called "Autofab," will be used by IBM in production of printed circuit subassemblies for the giant air defense computers the firm is building for the U.S. Air Force. Each of these computers requires thousands of these "building block" circuits. Preliminary production studies convinced IBM that the only way to meet desired USAF delivery dates was through automation.

Although the first Autofab machine will be used for national defense, it is immediately applicable to industrial use. General Mills scientists and engineers see in their machine, for example, wide utilization in commercial mass production of radio and television sets.

The Autofab machine achieves stepped-up output at lower cost and with increased quality. Its estimated capacity is more than 200,000 assemblies a month—based on a 40-hour week. Three people—two operators and a supervisor—can operate the basic Autofab machine.

The principal parts of the Autofab machine are a feeding mechanism for the printed-circuit base plates, 24 attaching heads complete with controls and components feeders, a conveyor system for moving base plates along the assembly line, a positioning mechanism for locating base plates under the attaching heads, and interlocks to insure proper sequencing. Power is supplied by a conventional electric motor and compressed air at normal factory pressure.

A companion machine to prepare and load components is under construction. The components, except polarized ones, are simply poured from the package into a hopper. The preparation machine straightens and trims leads, puts on wrap-around sleeves (for the IBM machine), and loads components into magazines that are simply hung on the attaching head turrets.

In operation the printed circuit feeder is loaded with base plates (capacity 400 plates with protruding lugs—more without lugs) and each of the 24 heads is filled to capacity (average 600) with separate components. All the attaching heads, controlled by a cam shaft, operate simultaneously. As each printed circuit plate reaches a position under an attaching head, the conveyor system stops momentarily, the head attaches its component and the conveyor resumes its progress. When the plate reaches the next head, the same operation is repeated until all 24 separate components have been attached.

For circuits carrying less than 24 components, only as many heads as are required are used. The system is completely flexible in this regard. It is not tailored to a single circuit and may be used for several hundred different assemblies.

After completing the full cycle, the fully assembled unit is fed onto a conveyor for the next operation, either inspection or automatic dip soldering. Loss of operating time is eliminated by use of multiple magazines on the base plate feeder and the attaching heads. Magazines are turned automatically so that when one is emptied of components, a full chamber immediately moves into operating position. The empty magazines then can be filled while the machine is running.

Quality control and avoidance of waste are achieved through uniformity in the attachment process and by automatic stoppage of the machine upon improper or incomplete attachment of any one of the separate components. When this occurs, a head may have exhausted its component supply and not been refilled through oversight on the part of the operator, so that a warning light flashes on that particular operating unit. Because of the signal, no time is lost in locating the trouble; and because the machine stopped, no material is lost.

Not only does the Autofab machine afford maximum safety in the assembly process, but its operating parts are easily accessible and require a minimum of maintenance, General Mills engineers say.

The machine can be adjusted to accom-

AUTOMATIC ELECTRONIC assembly machine can insert components into 20 assemblies a minute

AUTOMATIC ASSEMBLY LINE. (Left) printed circuit cards feed down onto the conveyor from the turret at the right and move down the line stopping in turn under each of 24 attaching heads to receive assorted electronic components. (Center) machine during insertion of a small resistor, showing a partially assembled plastic printed circuit card about to receive the resistor. (Right) completed roll off the line

COMPUTER CONSTRUCTION by International Business Machines that will use printed circuit assemblies from the General Mills automatic electronic assembly machine. This is IBM's experimental transistor computer

modate printed circuit plates of varying lengths and widths—either dimension variable from 2 inches to 10 inches. Minor design changes would permit use of other sizes. The attaching heads are interchangeable (attached by two bolts) and can be located in any station position in the line. They weigh only 25 pounds, which permits them to be carried easily by one man.

There are no shock loads or abrupt changes in velocity imposed on the circuit cards or the components. All attaching forces are applied directly to the component leads and none to the bodies, so damage to components is eliminated. The methods of shaping leads can be used on a wide range of components without major adjustments. Several modes of attaching components to the circuit cards are available—flat on the board, with a "stand-off" from the board, or mounted in holes spaced closer together than the length of the component.

Polarized components such as diodes, capacitors, and pulse transformers can be handled with proper orientation, because it is not possible to put magazines into the turrets backwards.

Publication Tells Causes for Dissatisfaction Among Engineers

If industrially employed engineers and management are to resolve their industrial relations problems without resort to the divisive influence of collective bargaining for professional personnel, the solution must emanate jointly from the professional engineering society, industry, and the professional engineers.

This is the conclusion of the Engineer-in-Industry Committee of the National Society of Professional Engineers (NSPE) in its recently-issued 128-page publication, "A Professional Look At The Engineer In Industry." The publication reviews the major causes of dissatisfaction among engineers in industry and the background and current status of drives to meet the engineers' problems by the development of engineers' unions.

The Committee's study suggests a series of remedial actions by management and individual engineers in the fields of professional status, employment conditions, and economic status. Among the suggested corrective steps are: a clear-cut distinction between professional engineers and subprofessional or preprofessional personnel; adapting industrial classification systems to professional status and duties; improved communications between management and its engineers; greater recognition of compliance with state engineering registration laws; more efficient utilization of professional employees; assignment of adequate clerical and technical assistance to professional engineers; improved training programs for engineers; elimination of "clock-punching" for the professionals; re-evaluation of industry's basic salary policies for engineers; action to alleviate the "leveling" of salaries between newly-hired and experienced engineering personnel; increased use of bonuses and other special financial rewards on an individual basis for outstanding achievements; and increased appreciation of the economic value of technical ability compared to administrative and supervisory functions. Forty-six specific areas for improving the engineer-management relationship are suggested.

The book recounts the specific engineering union activities and attitudes with respect to strikes, arrangements with trade unions, loss of leadership to nonprofessionals, advocacy of compulsory union membership, and the efforts of trade unions to organize professional employees.

In the field of economic remuneration, the Committee's report recognizes that the "most common complaint is that engineers are underpaid." A comprehensive review of economic data includes six illustrative charts of the trends in engineering salaries, as well as 11 tables of salary information from various sources. The economic review covers a variety of salary surveys by different groups, often conflicting in their findings, and official Government statistics on engineers' salaries. Comparisons are made with the economic level applicable to other professions and to skilled labor rates.

Whether the "middle ground" approach to the problems of engineers in industry, through the nonbargaining "sounding board" organizations of engineers, will provide an answer remains unsettled, according to the Committee. The book covers in some detail the legal question affecting the nonbargaining groups under the Taft-Hartley Act. The pending Kearns "Freedom of Association" Bill, supported by the NSPE, is noted and analyzed as a legislative solution to this unanswered question.

Other major aspects of the engineer–industry relationship treated in the book include engineering registration under state laws as a means of identifying professionals; various ethical aspects of union organization as related to professional employees; attempts by engineering unions to impose compulsory membership on other engineers; the attitudes of engineers toward unionization; and the relationship of engineers' unions to national defense development and production.

The book is documented by more than 250 footnote references. A bibliography and index is also included. The book is priced at $3.00 per copy and may be ordered from the National Society of Professional Engineers, 1121 15th St., N. W., Washington 5, D. C.

Westinghouse Steam Division Doubles Productive Capacity

Completion of Westinghouse Electric Corporation's $32-million expansion program at its Steam Division, South Philadelphia, Pa., has more than doubled the division's productive capacity for steam turbines and associated equipment. In addition, a new $6-million steam- and gas-turbine research and development laboratory has been completed.

In citing the need for the new facilities, W. C. Rowland, vice-president and manager of the Steam Division, pointed out that since the turn of the century, the electrical utility industry has nearly doubled its generating capacity every 10 years. "The division has increased eightfold its productive capacity for steam turbines in sizes from 10,000 to 20,000 kw. In the large sizes, our capacity will be more than doubled," he said.

"Perhaps the most significant contribution to the industry is our new research and development laboratory," Mr. Rowland said. "This will provide the means for intensive investigation of many of the problems that currently prevent major advances in design of steam and gas turbines . . ."

Heart of the plant expansion is the reactivated Merchant Marine facility adjoining the South Philadelphia works, which provides the division with 35 per cent more manufacturing area. This facility includes a huge single-story main building, a 4-story office building, and a modern boiler house. The main building, nearly 1/4-mile long, has more than 600,000 square feet of manufacturing area. It includes three high-bay manufacturing aisles 80 feet wide, and three machine-shop bays 48 feet wide.

The total additional area in these buildings will enable the assembly and testing of eight 250,000-kw central station unit at one

time. Up to 20 smaller units can be accommodated. The test stands are adaptable to any anticipated unit size (see cover).

One section is devoted to fabricating condensers and manufacturing, assembling, and testing coolers and heat transfer apparatus. Other parts of the same building will produce marine propulsion equipment and land gas turbines for electrical utility and industrial purposes. Separate machining, fabricating, and testing facilities are available for handling industrial gas turbines ranging in size and capacities. Large and small machine tools acquired total more than $10 million. Some of the larger machine tools include a 28-foot vertical boring mill, a 96-inch engine lathe, and a 10-foot planer-miller machine.

The new facilities also include a combination high- and low-temperature heat seasoning unit for turbine spindles. Costing over $1/2 million, it reproduces in the factory actual field operating conditions of rated speed and temperature. Electric heating elements will permit spindles to operate at temperatures of 1,300 F.

The new $6 million development laboratory has been functionally designed into several laboratories and special facilities. It consists of: machinery test hall for testing steam- and gas-turbine plants and components; closed-circuit wind tunnel powered by a 9,000-hp steam turbine for axial-flow compressor development; aerodynamics laboratory for investigating turbine and compressor blading and other special air- and steam-flow problems; combustion laboratory for gas-turbine combustion and corrosion study; heat exchanger and hydraulics laboratory; mechanical laboratory for vibration, control, mechanical, and lubrication studies; machine, woodworking, fabricating, and model shop; and high-pressure and -temperature boiler, supply line, and reheater.

A key part of the new laboratory is the instrument room, which contains more than $300,000 worth of the finest indicating, recording, and calibrating instruments available.

Symposium on Instrumentation to Be Held at Patrick Air Force Base

The American Ordnance Association's Proving Ground Instrumentation Committee is planning a 2-day symposium at Patrick Air Force Base, Eau Galli, Fla., April 14–15, 1955.

The symposium is specifically planned to be of interest to the Army, Air Force, and Navy, interested Government laboratories and instrument manufacturers, who have common interest in the following subjects: relative position of objects in space as a function of time; solution, recording, transmission, and reduction of data; environmental requirements of instrumentation; precision requirements of instrumentation; and operation research as it applies to planning of experiments or tests.

The technical program is being arranged by a committee headed by W. A. Wildhack, of the Bureau of Standards. The objective of the symposium is twofold; first, an interchange of information between interested Government agencies and industry; and second, to look at the long range needs for instrumentation. The security level of the meeting is Secret.

Experimental Transistors Are Assembled by Robot Device

A machine that can automatically carry out a series of more than 15 intricate steps in making experimental transistors is now in an early stage of development at Bell Telephone Laboratories.

The unique machine, familiarly known as "Mr. Meticulous," will do many operations in less than 1 minute. It takes a tiny bar of a special semiconducting material, such as germanium or silicon—a bar almost as thin as a human hair—examines it carefully for electrical characteristics and accepts or rejects it. If it accepts it, the machine fixes a fine gold wire to a critical point on the bar within an accuracy of 1/20,000 of an inch. Then, still within 1 minute, it connects this wire to one of the four wires leading out of the transistor, flips the bar end over end, repeats the entire operation with another wire on the opposite side, and finally runs a series of electrical tests on the completed transistor.

Transistors for research purposes must be of the highest precision and accuracy. When fashioned by human hands over any extended period of time, some transistors are produced which are substandard and useless for research purposes. This is the result of fatigue on the part of the technician. But "Mr. Meticulous" never gets tired, never loses his precision or accuracy. His hand never shakes and his highly organized electronic "brain" rarely has mental lapses.

The machine, originated by R. L. Wallace of Bell Telephone Laboratories, where the transistor was invented, may someday be a pilot model for industrial machines to be used in assembly-line transistor manufacture. At this stage, however, "Mr. Meticulous" is primarily a laboratory device designed to aid research on so-called "junction" transistors.

The commonest form of the junction transistor, now in production at the Western Electric Company's Allentown, Pa., plant, is a 3-layer "sandwich" of germanium sealed in a metal can a fraction of an inch in diameter. Wire leads connect to each of the three layers and extend outside the can. The junction transistor performs the same functions as some vacuum tubes—for example, it amplifies the voice and music signals received in a radio set.

A ROBOT DEVICE for assembling tiny experimental transistors, goes through his paces under the watchful eye of laboratories scientist R. P. Riesz. Inset shows a completed transistor compared with the edge of a United States dime. The wire shown is almost as thin as a human hair

Its three layers of germanium are alternately of two different electrical types: the two outside layers are of *n*-type (negative) germanium; the central layer is of *p*-type (positive) germanium. The two junctions of these different types of germanium give the transistor its name—junction transistor—and are the keys to its operation as an amplifier. An electric signal introduced at one end of the transistor can be amplified, passing through these layers if the proper electrical conditions are established.

The new type of transistor that "Mr. Meticulous" is currently assembling (although he can assemble other junction types as well) has a fourth wire which is attached to the central layer. For this reason it is called a "tetrode" or 4-element junction transistor. Such tetrode transistors are very promising for use at relatively high frequencies and for broadband applications such as television and large bundles of telephone conversations.

Industry Represented List of Best Managed Companies in 1954

Fifteen electrical machinery companies have been awarded Certificates of Management Excellence for 1954 in the sixth annual management survey by the American Institute of Management.

Listed in more than one subcategory were: Electric Auto-Lite Company, Toledo, Ohio; General Electric Company, Schenectady, N. Y.; McGraw Electric Company, Elgin, Ill.; Philco Corporation, Philadelphia, Pa.; Robbins and Myers, Inc., Springfield, Ohio; Sprague Electric Company, North Adams, Mass.; Sylvania Electric Products Inc., New York, N. Y.; Westinghouse Electric Corporation, Pittsburgh, Pa.; and Zenith Radio Corporation, Chicago, Ill. In communication equipment and related products were: Motorola, Inc., Chicago, Ill.; and Radio Corporation of America, New York, N. Y. In electrical appliances was Sunbeam Corporation, Chicago, Ill. In electrical generating, transmission, distribution, and industrial apparatus was Square D Company, Detroit, Mich. In insulated wire and cable was the Okonite Company, Passaic, N. J. In miscellaneous electrical products was Electric Storage Battery Company, Philadelphia, Pa.

These companies are among the 379 American and Canadian firms receiving the management citation after a continuing study of the operations of thousands of companies. In releasing the list, Jackson Martindell, president of the nonprofit research foundation explained that the institute examines a management in the areas of: economic function, corporate structure, health of earnings, fairness to stockholders, research and development, directorate analysis, fiscal policies, production efficiency, sales vigor, and executive evaluation.

Many Practical Applications Found for Ultrasonic Equipment

The science of ultrasonics is relatively new, and usage is expected to grow rapidly during the next few years. By definition, ultrasonics are those sound waves which are higher than the frequency of 16,000 cycles per second, and higher than any human ear can detect. Where the science of ultrasonics is concerned, engineers think of frequencies of the magnitude of 18 kc to as high as 500 mc. The frequency is determined by the purpose to be served and the type of material concerned.

Curtiss-Wright Corporation, Wood-Ridge, N. J., has more than a dozen fully developed applications for quality control, manufacturing, food processing, medicine and dentistry, brewing, and industrial and scientific research. To show the different requirements, ultrasonics has such diverse uses as inspection of a piece of steel 16 feet long, or homogenization of milk, or drilling through the hardest steels or ceramics.

ULTRASONIC PARTS WASHING UNIT quickly and thoroughly cleans objects difficult to handle by other methods. Ultrasonic waves loosen grime which is carried away in a continous flow

ULTRASONIC DRILL, that bores without rotating, can cut intricate shapes. In operation, the head moves imperceptibly up and down thousands of times a second to drive an abrasive solution into the work piece. No finishing or polishing is required

Curiously enough, while an ultrasonic wave has the ability to penetrate thick metal pieces and can traverse the length of a steel beam, the wave is disrupted by air space, even for a fraction of an inch. This phenomenon is the key to inspecting materials with ultrasonics. A flaw is generally a hole or void that cannot be seen. Ultrasonics can unerringly spot this defect below the surface and locate it accurately with respect to position and depth.

In other applications, ultrasonics relies on the harnessing of large numbers of vibrations per second to move the molecules of which all matter is composed. This explains its ability to mix liquids more thoroughly than normal mechanical means such as agitation.

Electronic instruments, similar to radio transmitters, are used to make ultrasonic waves by expanding and contracting a material able to convert electric energy into very-high-frequency mechanical oscillations or pulsations. These materials include magnetic metals, such as nickel, cobalt, and iron; certain crystals, including quartz; and some ceramics, such as barium titanate. When it is placed in a changing magnetic or electric field, the material changes its physical shape; in metals this is called magnetostriction. Crystals and ceramics with this property are known as electrostrictive or piezoelectric materials.

In the rapidly alternating field, the material expands and contracts at frequencies up to 500 mc, and is the source of the waves in the science of ultrasonics. From there on, the problem is simply one of applying a suitable soundhead—and there are many designs—directly to the material in work.

The ultrasonic tool cuts into the hardest metals and ceramics with a drill head of any desired geometric form. The method forcefully drives a fluid abrasive mixture into the piece being worked. The drill tip strikes several thousand times per second to penetrate the object, and it leaves a smooth interior surface, is cool in operation, and causes no change of physical, chemical, electrical, or metallurgical characteristics.

In other applications, the waves are applied to a liquid or fluid in which the work piece is suspended. This is the principle behind the parts washing machine that can clean or degrease parts so small and delicate that they cannot be properly done by hand.

SONOMETER, an ultrasonic "seeing eye," locates defects in materials. Operator watches meter for indication of any flaw discovered by sonic transmitting head and receiver, as she rotates part

International Symposium Planned on Modern Network Synthesis

The symposium forms a part of the celebration program commemorating the 100th anniversary of the Polytechnic Institute of Brooklyn. It will be held April 13–15, 1955, at the Engineering Societies Building in New York City as the fifth in a series which has been organized by the Microwave Research Institute.

The program will consider new advances in the synthesis of passive networks in the frequency and time-domains, new developments in the field of active and nonreciprocal circuits, and a round table discussion on the significance of new network synthesis techniques to the solution of design problems in industry.

The co-operation of the Institute of Radio Engineers and the cosponsorship of the Office of Naval Research, the Air Force Office of Scientific Research, and the Signal Corps permits this symposium to be held without admission charge or registration fee. "Proceedings of the Symposium on Modern Network Synthesis, II" will be published by October 1955 and may be ordered at a cost of $5.00 per copy.

Courses in Automatic Control Offered at University of Michigan

The University of Michigan, College of Engineering, has announced two intensive courses in automatic control. The first is scheduled for June 13 to 18, 1955, inclusive; the second for June 20 to 22, 1955, inclusive. The courses are intended for engineers who find it necessary or who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. The aim of the courses is to make it easier to learn by a coherent presentation of the fundamentals of modern automatic control and by providing a comprehensive set of notes to serve as a framework for further study.

The courses are built around the principles and application of measurement, communication, and control. Course I will consist of the fundamentals in each of these fields and will include some fundamental work in nonlinear systems. Course II will take up applications of the fundamentals to more advanced problems. There will be 4 hours of lecture each morning and 3 hours of laboratory demonstrations in the afternoon. Extensive use will be made of computing, instrumentation, and servo laboratories on the campus. The role of analogue computing methods will be emphasized.

April 15 is the closing date for registration. Further information may be obtained by writing to Professor L. L. Rauch, Room 1521, East Engineering Building, University of Michigan, Ann Arbor, Mich.

High School Science Teachers to Have Oak Ridge Summer Session

The Oak Ridge Institute of Nuclear Studies (ORINS) will present a summer institute for secondary school science teachers in Oak Ridge, Tenn., August 1–26, 1955. The summer institute will be sponsored by The National Science Foundation, and will be conducted by the ORINS Special Training Division.

The institute is intended to provide a selected group of approximately 48 teachers in the physical sciences an up-to-date review of scientific developments, emphasizing that science should be taught and learned as a whole rather than as a series of highly specialized and unrelated technologies.

Institute curriculum will include lectures and laboratory demonstrations in the fields of classical and modern physics; chemistry; mathematics and engineering; science experiments; science-teaching methods; radioisotope techniques and applications; and other selected subjects of interest to science teachers. The daily schedule of the institute will include three lecture hours in the morning and two each evening, with the afternoons and week ends reserved for informal and unscheduled conferences, library work, visits to points of interest in Oak Ridge, and recreational activities. It will be possible, during these unscheduled periods, for participants to use laboratory facilities to perform experiments and to familiarize themselves with radiation-detection equipment.

Financial assistance up to $215 will be granted to a number of selected participants. Deadline for return of application blanks is April 15, 1955. Application blanks and additional information may be obtained by writing Dr. Ralph T. Overman, chairman, Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

Energy Resources Is Theme of Fifth World Power Conference

The Austrian National Committee has been entrusted with the task of organizing the Fifth World Power Conference to be held in Vienna, Austria, June 17–23, 1956. With the concurrence of the other national committees, "World Energy Resources in the Light of Recent Technical and Economic Developments" has been chosen as the main theme of this plenary meeting.

The program has been drawn up so that, despite the great variety of topics under this theme, the Conference will be able to survey comprehensively the chief trends and the present state of development in the production and use of energy. The Conference will in this way be able to achieve its principal object of bringing about a better understanding among the experts of the various nations.

Subjects are divided into five main divisions: The State and Development of Power Production and Utilization in Individual Countries; Preparation and Conversion of Fuels; Utilization of Primary Sources of Energy; Purification of Waste Water and Waste Gas in the Production and Use of Energy; and International Collaboration in the Production and Use of Energy. Quota apportioned to the United States National Committee (World Power Conference, c/o Engineers Joint Council, 25–33 West 39th Street, New York, N. Y.), amounts to 20 to 30 reports, and titles are to be submitted to them before April 30, 1955.

Communications and inquiries concerning the Fifth World Power Conference may be addressed to the Oesterreichisches Nationalkomitee der Weltkraftkonferenz, Vienna I, Schwarzenbergplatz 1, Austria.

Power and Electronic Equipment to Be Exposed to Atomic Tests

The effects of an atomic explosion on electric service lines and electronic equipment will be tested in April. The atomic tests are to be conducted in the Nevada desert, some 90 miles from Las Vegas.

The invitation to participate in the test was extended to several organizations by the Federal Civil Defense Administration under whose direction the test will be made. Data is expected to provide valuable information to electrical utility designers and electronic equipment engineers in their civil defense studies and planning.

The Edison Electric Institute is concerned with the potential effects of atomic bomb blast pressure on electric transmission and distribution lines, substations, and other facilities serving the electrical consumer. To obtain the desired information duplicate installations at different distances from the test explosion, as well as outside the area of total destruction, will be constructed. Each installation is based on a transformer substation of the kind found in most communities. Power lines will run from the poles to the houses being tested. Parts of the system will be energized during the detonation.

Radio Corporation of America (RCA) will provide a standard commercial 250-watt radio transmitter and associated equipment for a fully-operative AM radio broadcast station, a complete mobile radio base station operating in the 25- to 50-mc range, and two mobile radio units installed in automobiles. The RCA radio equipment will be installed in concrete houses and located in an area which is expected to suffer nearly total building destruction.

Scientists Make Small Diamonds in Industrial Research Laboratory

Scientists of the General Electric Research Laboratory recently exhibited tiny diamonds made from a carbonaceous material subjected to extreme pressures and temperatures. The largest stone, which measured 1/16 of an inch longest dimension, was presented to Ralph J. Cordiner, president of General Electric Company, by Dr. C. Guy Suits, General Electric vice-president and director of research.

In announcing what he termed "one of the landmarks in man's search for knowledge about his world," Dr. Suits warned that "any conclusion we are about to make diamonds of a size and quality suitable for gem use is decidedly premature." Diamonds for jewelry must have special characteristics of size, color, and crystal perfection.

"On the other hand," he added, "if the

ONE-THOUSAND-TON PRESS for achieving high pressures (100,000 atmospheres or 1.6 million pounds per square inch). This is the apparatus in which the man-made diamonds were first produced

MAN-MADE DIAMONDS were exhibited publicly by scientists at the General Electric Research Laboratory. Dr. C. Guy Suits, vice president and director of research, is shown with Drs. Herbert M. Strong (left) and H. Tracy Hall (right), successful pioneers in the search for diamond-making methods and formulas

present high cost of making diamonds by the General Electric processes can be reduced, the primary application of man-made diamonds will probably be in industrial tools for cutting and polishing." Diamonds of any quality, regardless of size and color—including diamond dust—are useful in industry. The crystals displayed are not "imitation" diamonds or "diamond-like." They are purely and simply diamonds, exactly the same as are taken from mines of the Belgian Congo and Brazil.

The hardest substance known to man, diamonds are mined at the rate of about $2^1/_2$ tons annually. Approximately 90 per cent are imported by the United States. Of the diamonds of industrial grade, some are stockpiled for defense purposes, but the major portion goes into tools that cut, saw, or polish other hard materials. For industrial diamonds purchased in a typical year, the United States paid more than $50 million.

According to Dr. A. L. Marshall, manager of the laboratory's chemistry department, the General Electric diamonds were positively identified by X-ray inspection, chemical examination, and hardness tests. Under hardness tests, the diamonds proved capable of scratching anything, even other diamonds.

Making diamonds was the result of more than 4 years of intensive research by laboratory scientists under supervision of Anthony J. Nerad, manager of the mechanical investigations section. "General Electric's success was no accident," he said, "but a part of a general program for examining various materials subjected to combined high temperature and pressure."

The scientists responsible for the project were Drs. Francis P. Bundy, H. Tracy Hall, Herbert M. Strong, and Robert Wentorf. In Dr. Strong's process, a carbonaceous compound was subjected for many hours to a measured pressure some 53,500 times greater than atmospheric (roughly 800,000 pounds per square inch). That run, in the laboratory's new 1000-ton press, yielded a crystal.

"After opening the pressure chamber," said Dr. Strong, "and while attempting to polish the now solidified matrix, there appeared what we were seeking—a core of superhard matter that refused to wear away under the action of the polishing wheel. With considerable excitement and expectation I removed the crystal from its surroundings, and tried one of its sharp points on sapphire, silicon carbide, and boron carbide. This 'diamond,' I could call it now, easily scratched all three."

Of fundamental importance was the work of Dr. Hall, who extended Bundy's initial high-pressure work and developed the "belt," a chamber enabling General Electric scientists to maintain for the first time temperatures above 5,000 at pressures in excess of $1^1/_2$-million pounds per square inch.

This pressure is roughly equivalent to the "squeeze" physical scientists have computed for points 240 miles beneath the earth's surface. Using this equipment, late last year Dr. Hall developed a process that produces diamonds in a matter of minutes. Hall's diamonds are smaller, but are often produced in solid clusters. Single runs have produced up to 1/10 of a carat.

Dr. Wentorf likewise had success with the same physical apparatus employed by Hall, though different chemical conditions were present. Since these achievements, several new methods have been tried, and these also produce diamonds.

Dr. Marshall, in the course of discussing laboratory tests for diamonds, explained that x-ray examination is perhaps the most conclusive single test, because every crystal from common salt to precious jewel has its own distinctive x-ray "fingerprint," or diffraction pattern. It is easy to recognize the pattern of diamond because no other known material comes anywhere near matching it.

General Electric attaches great importance to the possibility of producing diamonds as a logical extension of its interest in hard cutting materials represented by cemented carbides produced in its carboloy department.

Armour Research Foundation Plans Reactor for Industrial Research

A new million-dollar laboratory building, to house Armour Research Foundation's electrical engineering research facilities and proposed nuclear reactor, got into construction about mid-March, with completion scheduled for October 1. The reactor will be the first such facility entirely for industrial research problems.

Seven industrial companies have signed as participators in the nuclear reactor research program: Arc Equipment Company, Bryan, Ohio; Armour and Company. Chicago, Ill.; Borg-Warner Corporation, Chicago, Ill.; Elgin National Watch Company, Elgin, Ill.; Illinois Tool Works, Chicago, Ill.; Richardson Company, Melrose Park, Ill.; United States Steel Corporation, New York, N. Y. Armour Research Foundation intends to sign at least eight more industrial firms as participators in the program.

Under the reactor plan, each participating firm will make an initial payment of $20,000; in return, the companies will share in the benefits derived from the nuclear reactor research program for 3 years after the reactor starts operation.

"We are gratified by industry's prompt acceptance of the nuclear reactor as a new tool for research," said Dr. Haldon A. Leedy, director of the Foundation. He said the diversity of the participating companies shows the wide interest in the potentialities of the reactor and suggests the impact nuclear energy will have on industry.

Nuclear Reactors to Be Studied at University of Michigan

The University of Michigan announces a 2-week intensive course on Nuclear Reactors and Radiations in Industry to be given August 15 to 26, 1955. The course is sponsored by the Nuclear Engineering Committee of the College of Engineering, and will be conducted by members of the Engineering College staff, assisted by guest lecturers.

Lectures covering such topics as elementary nuclear theory, measurements of nuclear radiations, interaction of radiation and matter, and nuclear reactors and fuels will be co-ordinated with laboratory demonstrations, tours of University radiation facilities, and examples of industrial applications.

The course is intended for the engineer without previous experience in nuclear technology who wishes to acquire a knowledge of representative problems and techniques in this rapidly developing field. Tuition will be $200. For further details or for information on application, write Professor William Kerr, Department of Electrical Engineering, University of Michigan, Ann Arbor, Mich. The deadline for registration is June 1, 1955.

Arc Welding Foundation Offers Machine Tool Design Award

The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, is sponsoring a Machine Tool Design Award Program to stimulate scientific research in arc welding and its use in machine tool design and construction. The Foundation offers 15 awards totaling $12,000 for the best papers describing the use of arc welding in the design of a component part or a complete machine tool. Awards will be made as follows to authors of papers selected by the Jury of Awards: First Award, $3,000; Second Award, $2,500; Third Award, $2,000; Fourth Award, $1,500; Fifth Award, $1,000; and 10 Honorable Mention Awards of $200 each.

The Award Program is open to all persons

in the United States and its possessions who have been engaged in the design or manufacture of the equipment. To qualify as subject matter the equipment must have been either designed or redesigned or manufactured within the period January 1, 1953 to July 15, 1955. All communications relative to the program shall be addressed to: Secretary, The James F. Lincoln Arc Welding Foundation P. O. Box 3035, Cleveland 17, Ohio.

Human Engineering Institute Will Have Interesting 5-Day Program

A 5-day Human Engineering Institute will be conducted by Dunlap and Associates, June 6–10, 1955, in Stamford, Conn. Such subjects as human capabilities and limitations as factors in equipment design; human motor performance; body measurements and workplace layout; and effects of operator and maintenance personnel specifications on design will be considered. The registration deadline is May 6, 1955. For complete information write to Dr. Martin A. Tolcott, Dunlap and Associates, Inc., 429 Atlantic Street, Stamford, Conn.

Technical Writers' Institute Has Sessions on Handbooks

The third annual Technical Writers' Institute will be held at Rensselaer Polytechnic Institute, Troy, N. Y., June 13–17, 1955.

In the last 2 years nearly 100 representatives of 63 companies have attended the two previous sessions of the Institute, which is designed for those who supervise technical writing in business and industry, educational programs, and technical promotion. It also gives instruction and refresher work for those newly entering the field.

Included in the courses are sessions on manuals and handbooks, reports, company public relations, and associated fields. The week is devoted to lectures by outstanding authorities, personal consultations, group discussions, and writing practice exercises. A staff of eight from the Rensselaer faculty conducts the Technical Writers' Institute under the directorship of Jay R. Gould.

Corporation Schedules Computer Scholarship Program for Summer

To provide a "meeting of minds" between tomorrow's technologists and the electronic "brains" behind America's new industrial revolution, ElectroData Corporation of Pasadena, Calif., announced its second annual University Scholarship Program in computers to be held June 7–September 2, 1955.

The financial aid program, for selected students at leading universities, will comprise training in the structure and operation of digital computers, practical numerical analysis, the theory of programming and coding, industrial computer applications, and management of computer companies.

Students will take the 10-week course at the Pasadena headquarters of ElectroData Corporation, manufacturers of high-speed electronic data processing machines. Overall direction will be by Dr. Paul Brock, ElectroData technical services manager and chairman of the Southern California Section of the Society for Industrial and Applied Mathematics.

Records of no more than two students from any one university should be submitted before April 15 for evaluation by department heads. Address applications to Dr. Paul Brock, ElectroData Corporation, 717 North Lake Avenue, Pasadena, California. For each student selected to attend the course, ElectroData will grant $500 to the individual's university.

New Automatic Controller Used for Machine Tool Operations

A new compact automatic digital controller that can be used to control machine tool operations, conveyor belts, batch mixing operations, or hold aircraft or refinery valves within preset limits has been developed by American Electronic Manufacturing, Inc., Culver City, Calif., instrument division of American Electronics, Inc.

Heart of the new controller is a unit 7 inches high, 10 inches wide, and 8 inches deep with a capacity of 2,500 counts, which adds and subtracts automatically at rates up to 20 decimal digits per second with an accuracy of 0.04 per cent. The count at any instant is shown on four illuminated windows by a new type of indicator tube, the Inditron.

In a typical machine tool operation, this controller was developed in conjunction with Sheridan-Gray, Inc. to be used on their line of stretch forming machines. A sheet of aluminum is placed in the stretcher and a small transmitter establishes a digital count as the machine is operated manually from start to completion of the metal-forming operation. The transmitter, consisting of a mechanical switch and capacitor, sends pulses to a thyratron in the controller, and the count is noted at the start and stop of the operation. Then, for succeeding operations, the stretcher is controlled by these counts preset by switches on the controller. The operator of the machine thereafter places a piece of aluminum in the stretcher, and at the correct count the controller starts a motor switch for the forming operation. This operation proceeds automatically until the transmitter sends the final count and automatically stops the motor. One man can supervise the operation of several machines simultaneously and assure uniform production.

This controller also solves the problem of counting items on two conveyor belts, one belt feeding the other and both operating at different speeds, as frequently encountered in industry. Similarly, in a mixing operation, with 10 batches of solution *A* to be mixed with 25 batches of solution *B*, a count of 10 triggers the controller to permit an input from *B* and when the count reaches 35 (10 plus 25) the controller switches the input back to *A*. In a process control operation, where a pressure is measured by a transducer or a temperature by a thermocouple, the new controller makes it possible to preset upper and lower limits beyond which the variable pressure or temperature must not go.

Advantages claimed for the new controller include its relatively high speed of up to 20 counts per second, as against most mechanical counters which are limited to speeds of 10 counts per second or less. Accuracy is 1 count in 2,500, or 1 in 25,000; that is, 0.04 per cent or 0.004 per cent.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Harmonic Analysis

To the Editor:

L. W. Lewis's article in the January, 1955, issue of *Communication and Electronics*, paper **54-512**, titled "Harmonic Analysis of Nonlinear Characteristics," is the hallmark in a new approach to the dynamics of nonlinear systems from the standpoint of what already is accumulated on linear systems. It ties the two together so that nonlinear elements can now be regarded as frequency converters—such as synchronous converters, which in this instance regenerate a whole series of harmonics, in lieu of excitation at only a single harmonic, called the fundamental, or a set of sum and difference frequencies for more complex periodic excitation, as a pair of sinusoids. The elegance of his presentation compares, in my opinion, with that of Fourier's series. He has done an elegant job of a formidable task with remarkable completeness.

Mr. Lewis has opened the way for extended work in synthesis by his method of transients in linear systems which contain nonlinear elements of this kind in lumped form. The analysis application however probably is more important to our general knowledge. Now the nonlinear response characteristics of the human hearing system can be formulated as a mathematical function from experimental data on harmony in music, and that art is bound to benefit.

JOSEPH C. ADAMS

(178 Hicks St., Brooklyn, N. Y.)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

PROFITABLE SMALL PLANT MANAGEMENT. By Malcolm H. Gotterer. Conover-Mast Publications Inc., 205 East 42nd Street, New York, N. Y., 1954. 318 pages, 8½ by 5⅞ inches, bound. $5.50. A book of basic principles intended for the manager of small or medium-sized plant. It will be useful to those planning a cost reduction or management development program, and to those who must supervise the work of employed specialists, or who wish to acquire a general knowledge of scientific management. Concisely dealt with are plant layout, production control, manpower management, job evaluation, cost control, and other phases of the subject.

SERVOMECHANISM PRACTICE. By William R. Ahrendt. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 349 pages, 9¼ by 6¼ inches, bound. $7.00. Written to supplement the theory taught in college courses on the subject, this is a practical book covering circuiting, components, and problems of design and manufacture. It includes chapters on the operation of a simple servomechanism, types of error detectors, electrical and electromechanical components, magnetic and rotating motor-generator amplifiers, and hydraulic systems. A complete description of a typical instrument servomechanism is given.

TABLE OF SINE AND COSINE INTEGRALS FOR ARGUMENTS FROM 10 TO 100. (Applied Mathematics Series, no. 32). National Bureau of Standards. Superintendent of Documents, Government Printing Office, Washington 25, D. C., 1954. 187 pages, 10½ by 8 inches, bound. $2.25. The values of the sine and cosine integrals are tabulated to 10 decimal places for the range between 10 and 100, at intervals of 0.01. This is a reissue of the table with the same title prepared by the Works Progress Administration Mathematical Tables Project, with some changes in the auxiliary tables. The customary bibliography and explanatory introduction are included.

WELDING OF PLASTICS. By G. Haim and H. P. Zade. MANUAL FOR PLASTIC WELDING—POLYETHYLENE. By G. Haim and J. A. Neumann. (Welding of Plastic Series, volumes I and II, 1947 (London), 1954). Available from The Industrial Book Company, 1240 Ontario Street, Cleveland 13, Ohio. 206 pages, 128 pages, 8¼ by 5⅛ inches, bound. Each volume $6.00. The first of these volumes in the Welding of Plastics Series covers general aspects: chemistry and physics of weldable plastics and their technology; hot gas, heated tool, high frequency, and other welding processes; seam welding machines; and industrial applications in the chemical industry, in packaging, etc. Volume II is a discussion of welding of polyethylene and its applications with separate chapters devoted to tank linings and pipe lines.

ALTERNATING-CURRENT MACHINES. By A. F. Puchstein, T. C. Lloyd and A. G. Conrad. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., third edition, 1954. 721 pages, 9¼ by 6¼ inches, bound. $8.50. This revision is similar in scope and character to previous editions, with consideration of only steady-state phenomena, and with the following topics treated for the various types of machines: construction, operating characteristics and their calculation from tests, and discussion and analysis of related phenomena. Principal changes are new methods of approach to theory and additional material on adjustable-speed drives, rectifiers, and self-synchronous machines.

ANALOG METHODS IN COMPUTATION AND SIMULATION. By Walter W. Soroka. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 390 pages, 9¼ by 6¼ inches, bound. $7.50. Describes mechanical, electromechanical, electrical, and electronic analogue components for various arithmetical processes and shows how these are combined into analogue computers for solving various types of equations. The mechanical differential analyzer and electronic analogue computer are discussed, and there are chapters dealing with dynamical analogies, finite difference networks, membrane analogies, and conducting sheets as applied in the simulation of physical systems and solution of differential equations.

ATOMIC AND FREE RADICAL REACTIONS, VOLUMES I AND II. (American Chemical Society Monograph no. 125.) By E. W. R. Steacie. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., second edition, 1954. 901 pages, 9¼ by 6¼ inches, bound. $28.00/2 vol. The first volume is a general discussion of experimental methods and of the role of atoms in thermal and photochemical reactions, and also presents a systematic survey of data pertinent to the rates of individual elementary reactions. The second volume deals with specific elementary reactions of systems containing carbon, hydrogen, oxygen, nitrogen, chlorine, bromine, iodine, sodium, other metals, and sulphur. The book includes a reaction index and an extensive bibliography.

BIBLIOGRAPHY ON RESEARCH ADMINISTRATION-ANNOTATED. By George P. Bush. University Press of Washington, D. C., Washington 4, D. C., 1954. 146 pages, 9¼ by 6¼ inches, bound. $4.00. Includes more than 1,100 selected references to periodical articles and books mainly published in the United States since 1945. Arrangement is alphabetical by author in eight broad sections—for example, budget and finance, organization and management, personnel, and external relations. There is an author and a topical index.

COMMUNICATION IN MANAGEMENT. By Charles E. Redfield. University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill., 1953. 290 pages, 8¼ by 5⅜ inches, bound. $3.75. This book deals with the communication problems of the executive in any type of large-scale organization. The five parts cover types of information communicated, transmission of information from superior to subordinates, reporting to the central headquarters, communication between departments, and theory and techniques. Chapter bibliographies are included.

DEVELOPING MANAGEMENT ABILITY. By Earl G. Planty and J. Thomas Freeston. Ronald Press Company, 15 East 26th Street, New York 10, N. Y., 1954. 447 pages, 9¼ by 6½ inches, bound. $7.00. Questions dealing with specific problems of many types of enterprises, and actually asked by executives, are given practical answers embodying the ideas and practices used by training men today. The questions are grouped in four parts covering methods and types of managerial development, organizing and operating a training program, and evaluation. A selected bibliography is included.

NATIONAL ELECTRICAL CODE HANDBOOK. By Arthur L. Abbott, revised by Charles L. Smith. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., eighth edition, 1954. 642 pages, 8½ by 5½ inches, bound. $6.25. A guide for the user of the Code, this manual is aimed at promoting better electrical installations in the interest of safety to persons and property. It contains basic minimum requirements for installations in general, for those involving special occupancies, special equipment, or other special conditions, and for installations of communications systems. A separate chapter is devoted to construction specifications. The text is arranged according to the numbering system of the 1953 Code and includes explanations of Code rulings.

THE NATIONAL FIRE CODES, 1954. Volume V: Electrical. National Fire Protection Association (NFPA), 60 Batterymarch Street, Boston 10, Mass., revised, 1954. Various paging, 8⅞ by 5⅝ inches, bound. $6.00. This volume includes the National Electrical Code as adopted in 1953 and standards on electrical fire alarm and supervisory service, lightning protection, and static electricity. Electrical provisions from other NFPA standards are included in the form of an index to the complete texts published in various volumes of the National Fire Codes.

THE NATIONAL FIRE CODES, 1954. Volume VI: Transportation. National Fire Protection Association (NFPA), 60 Batterymarch Street, Boston 10, Mass., revised, 1954. Various paging, 8⅞ by 5⅝ inches, bound. $6.00. A compilation of NFPA standards in the field, together with certain associated subjects. It includes a summary of pertinent government regulations, and standards for fire protection and prevention for transit operations, piers and wharves, motor craft, petroleum wharves, tank vehicles for flammable liquids, industrial trucks, etc.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

The Electrical Properties of Glass Fiber Paper-II. Fillers that will double or triple the strength of glass fiber paper, and binders and saturants producing even greater strengths are among the developments in glass-fiber paper technology described in this review of the industry. Research described in this report is aimed at encouraging quantity industrial production of superfine glass fibers for use in filter papers, dielectric papers, and nonflammable products. Included is a summary of private research that has developed, among other products, fibers having toxic qualities toward bacteria and fibers for use as lightweight shields against thermal neutrons and gamma radiation. Effects of fiber diameter, blends and pH of stock on mechanical strength are discussed. A special section analyzes commercial availability of both fibers and paper. 27 pages. $.75. This is available from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (Commerce Building, Room 6227.) Code number of report is PB 111310.

A Digital Electronic Data Recording System for Pulse-Time Telemetering. New equipment for high-speed recording and reduction of telemetered information is described in this Air Force report. The system is designed for use with Aerobee rocket flights gathering upper-air data. However, a modified system would be useful for recording large quantities of laboratory data or for accurately recording data at a safe distance from hazardous operations. The system consists of two units. Diger I accepts the telemetered data, converts it into coded digital form, and provides a permanent film record. A print of this record is fed into Diger II, which reads the coded data photoelectrically and simultaneously produces typewritten tabulations of the telemetering voltages. Typing speed is about 1/300th of the recording speed. The two units are illustrated with photographs and schematic drawings. 47 pages. $1.50. Copies are available from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (Commerce Building, Room 6227.) Code number of report, PB 111294.

Television Recording System. Of potential commercial importance is a new film-recording system for photographing television programs described in this report from the Naval Research Laboratory. Portable and versatile, the new system permits storing of televised information for a more detailed analysis than is possible in direct viewing. Operating at the standard 24-frame-per-second recording rate, the new system can photograph as much as 80 per cent of the televised data. A free-running and shutterless camera is synchronized with an electronically controlled device that blanks and unblanks the cathode-ray tube in the camera. The system is adaptable to a wide variety of television line and frame rates. 29 pages. $.75. To obtain this government report, write to Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (Commerce Building, Room 6227.) Code Number of report is PB 111307.

INDUSTRIAL NOTES ....

Impulse Generator Installed. The Victor Insulator Division, I-T-E Circuit Breaker Company, Victor, N. Y., has installed a 8,000,000-volt impulse generator. The bank consists of eight 100,000-volt capacitors, transformer and rectifier, and a model *293* Dumont oscillograph for showing waveforms, plus a 4- by 5-inch camera for recording these waves on film. The impulse generator is part of a $150,000 laboratory expansion program.

New Defense Plant. Robinson Aviation, Inc., Teterboro, N. J., has signed a 20-year lease agreement with the Port of New York Authority for construction by the Authority of a new 42,000-square-foot factory to handle Robinson production. The factory will cost $425,000, exclusive of land value, and will be located on Teterboro airport's northeast corner, the first structure of a new road entering the airport at right angles from Route U.S. 46. The company has specialized in vibration control engineering and manufacturing.

Ketay Instrument Merges With Norden Laboratories. Ketay Instrument Corporation has merged with The Norden Laboratories Corporation, and Morris F. Ketay has been named president of the combined companies. At a board meeting the following officers were named: Paul W. Adams, chairman of the executive committee and executive vice-president; Benjamin Gross, chairman of the board; Malcolm V. Lane, treasurer; and Jack Standler, secretary. The newly elected directors are: P. W. Adams, Carlyle F. Barnes, Albert Parker, and Louis T. E. Thompson. Present directors include Gordon Dean, Frank Manheim, and Henry A. Getz.

AMF Leases Greenwich Building. American Machine and Foundry Company has expanded its development engineering operations in Greenwich, Conn., with the leasing of 27,000 square feet in the Fawcett Building in Greenwich. Approximately 200 engineers and supporting personnel will eventually occupy these new offices. The company's Greenwich engineering department is engaged in engineering research and development, work in radar antennas, ordnance, guided missiles, and plant automation.

Instrumentation Orientation Course. A one-week industrial instrumentation course given free of charge periodically by Fischer and Porter Company at the Hatboro, Pa., plant has been completed by nine technicians from various industries located in seven northeastern and middle-western states. The course covered a general orientation of the application of instrumentation to industry, the theory and calibration of the variable-area flow meter, and the design, nomenclature, function, and maintenance of industrial control instrumentation. A plant tour familiarized students with instrument manufacturing. A reservation for participation in the next training course may be made by contacting any local Fischer and Porter office, or writing to the service manager, Fischer and Porter Company, Hatboro, Pa.

Studebaker-Packard Acquisition. Studebaker-Packard Corporation has entered the field of scientific research and development, emphasizing defense products, with acquisition of the Aerophysics Development Corporation of Los Angeles, Calif. Aerophysics will be a subsidiary of Studebaker-Packard and will be headed by its founder, Dr. William Bollay, as president. Aerophysics Development Corporation, currently doing defense development work for the government, is known for its activity in the guided missile field in which it has specialized.

General Electric News. A 20-million-dollar manufacturing plant to enlarge Transformer Division facilities has been announced. The plant will eventually employ 1,100 persons, and will be located in the Hickory-Newton-Conover area of North Carolina.

Harold L. Blom has been appointed manager of marketing administration for communication equipment. He will develop and carry out marketing administration programs and policies which include forecasting sales and scheduling production.

The appointments of Paul D. Johnson, James H. Cutter, George V. Sheppard, Jr., and James W. Brooks, Jr., have been announced. Mr. Johnson has been assigned to the North Central District with his office at 531 West College Avenue, Appleton, Wis. Mr. Cutter will cover Cleveland. His office will be at 1817 Brookpark Road, Cleveland, Ohio. Mr. Sheppard has been assigned to Charlotte, N. C., and will have his offices at 1300 Berryhill.

Automatic electronic warfare was highlighted when the company formally opened a 100,000-square-foot systems center for its heavy military electronic equipment department. The center will serve as headquarters for development and manufacturing operations on powerful, extensive electronic "nerve centers" for military use.

Electronic Systems Division Established. Sylvania Electric Products, Inc., has established an Electronic Systems Division, which becomes the company's ninth operating division. Henry Lehne has been named general manager of the new division. He has been director of Sylvania's electronic defense laboratory in Mountain View, Calif. Norman L. Harvey will serve as assistant general manager and chief engineer. Present operations are con-

(*Continued on page 22A*)

—*Now ready:*—

Volume II of

Servomechanisms and Regulating System Design

By HAROLD CHESTNUT and ROBERT W. MAYER, both of the Aeronautics and Ordnance Systems Division of the General Electric Company

Now, in Volume II, this comprehensive work is completed with the information needed by the servo design engineer to cope with both the analytical and practical aspects of design. The authors state the problems met in design, then develop methods for their solution. Emphasis is on the practical aspects, but analytical proofs are provided where they are needed. The book also provides the results which have been achieved by designers even though these may not be backed up by analytical proofs.

Stresses Handling of Non-Linear Problems

Information on measurements is presented early in the volume to serve as a quick review of some of the material in Volume I and because it is essential in the study of servomechanisms. Similar stress is also laid on techniques for handling the effects of extraneous signal inputs and on the factors influencing the selection of elements for power and stabilizing sections. There is ample material on the subject of linearization techniques and on non-linear operation for large input signals and deliberate parameter changes.

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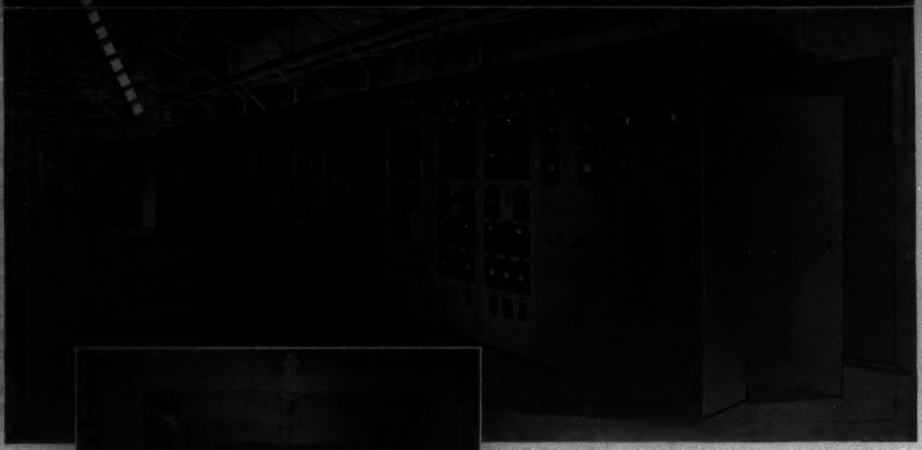
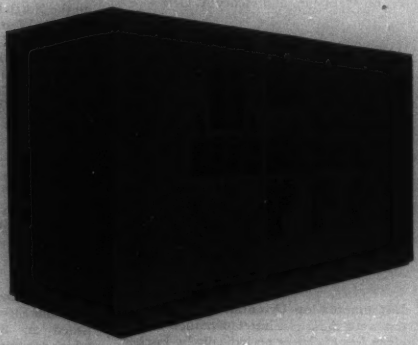


Manufactured in two sections, this duplex control and relay switchboard is shown on factory assembly floor.

Interior of one section of the above switchboard is illustrated at left.

Observe attractive appearance of this NELSON duplex switchboard.



NELSON Duplex Control and Relay Switchboards are designed for metering, instrumentation and control of substations and generating stations.

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Wire guttering can be furnished with or without covers. Wiring on the rear of the panels is secured by flash welded studs in order to assure a smooth front surface.

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NELSON Electric MANUFACTURING CO.
TULSA, OKLAHOMA

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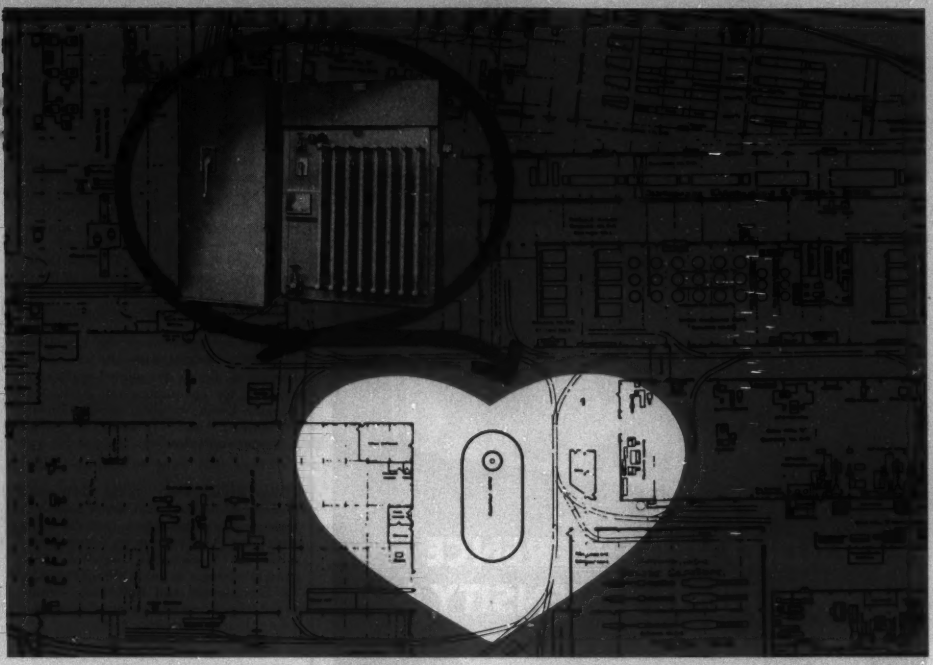

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Uptegraff announces a complete line of *Liquid Filled* LOAD CENTER TRANSFORMERS—150 KVA to 2500 KVA, 3 phase—designed for convenient installation with various types of switching equipment and terminal arrangements.

The use of Uptegraff Load Center Transformers offers savings up to 15 per cent as compared to the practice of using remote outdoor transformers to supply low-voltage power to machines and equipment located indoors. With load center transformers, costly low-voltage runs are kept to the minimum, and power characteristics are improved.

Uptegraff Load Center Transformers are designed and built specifically for this class of service. In addition to savings in installation costs, they offer substantial economies through operating efficiency. They are dependable and require the minimum of maintenance.

R. E. Uptegraff Manufacturing Co.

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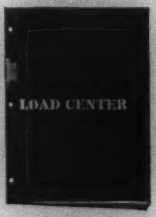
NEW HANDBOOK

The new Uptegraff Load Center Transformer Handbook simplifies the selection of a suitable unit, including auxiliary terminal equipment to provide the facilities you require. It gives overall dimensions and weights (including terminal devices, etc.) for all ratings from 150 to 2500 KVA,—3 phase. Write for a free copy. The coupon below is included for your convenience.



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RADIO INTERFERENCE
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Stoddart NM-10A • 14kc to 250kc
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Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc

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Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has BFO.

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(*Continued from page 17A*)

cerned with development and production of electronic systems and equipment for military services. Headquarters of the new division will be at 175 Great Arrow Avenue, Buffalo, N. Y.

New Appointments. Two appointments in the government field engineering department of Raytheon Manufacturing Company, Waltham, Mass., were announced recently. Edward K. Koherr was appointed assistant director to handle field service requirements. G. Edward Dodge, formerly administrative assistant to the director of government field engineering, has been named government field engineering supervisor.

Three appointments in the Equipment Marketing Division were also announced. Donald W. Smith was named applications engineer for communications equipment; Bernard Levin, technical information representative; and William H. Buck, catalogue supervisor.

Philco Promotions. Philco Corporation announces the appointments of Joseph A. Lagore as vice-president, manufacturing, and James D. McLean as vice-president, sales. For 3 years, Mr. Lagore has been general manager in charge of operations of the Government and Industrial Division. Mr. McLean has been general sales manager of that division since 1949.

IBM Promotion. The promotion of Jay W. Schnackel to vice-president in charge of manufacturing has been announced by International Business Machines Corporation (IBM). Mr. Schnackel joined IBM in 1937, and was general manager of the company's Endicott, N. Y., plant. He is succeeded by Arthur L. Becker, former assistant general manager, who joined the company in 1931.

NEW PRODUCTS . .

Silicone Rubber. Copper-clad silicone-rubber laminate with desirable electrical and mechanical properties has been developed by Oliver Tire and Rubber Company. This new base material is composed of copper foil up to 0.003 inch thick, bonded securely to one or both sides of silicone rubber from 0.010 to 0.100 inch in thickness. Present sheet size is 12 by 48 inches. The chemical and heat resistance of silicone rubber allows acid or ferric chloride etching with subsequent dip soldering. Flexibility makes it possible to stencil and etch on a plane and later to form the circuit-carrying surface around a mandrel for most efficient use of available space. For further information write: Industrial Rubber Products Division, Room 7-E, Oliver Tire and Rubber Company, 4341 San Pablo Avenue, Oakland 8, Calif.

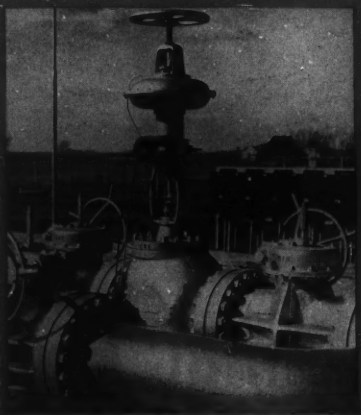
(*Continued on page 30A*)

..boosts Platte Pipe Line efficiency!

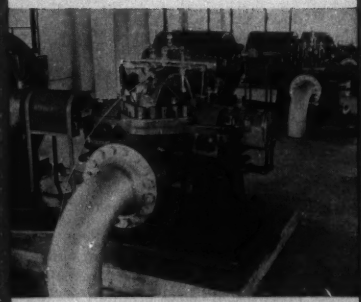
The Philco microwave system of the Platte Pipe Line Company—the largest and most comprehensive installation of its kind—demonstrates the economic advantages of microwave better than any other pipe line microwave system in the nation. Here is what A. R. Heidebrecht, Chief Engineer of Platte, has to say about the system: "Our decision to use microwave was greatly influenced by the number of pipe line control functions which could be accomplished remotely and automatically. Operation to date has proved very successful; in fact, during the short time this system has been in use, the efficiency of our pipe line operation has been substantially increased."

Perhaps microwave can lower operating costs and boost the efficiency of your plant. Philco maintains a staff of experienced field and system engineers who can help plan and install your microwave system. Get information on the many leading Philco microwave installations in use today. Write to Philco, Dept. EE.

Platte Pipe Line control center at Kansas City.



Microwave operates valves along the pipe line.



Pipe line pump station operated by microwave.

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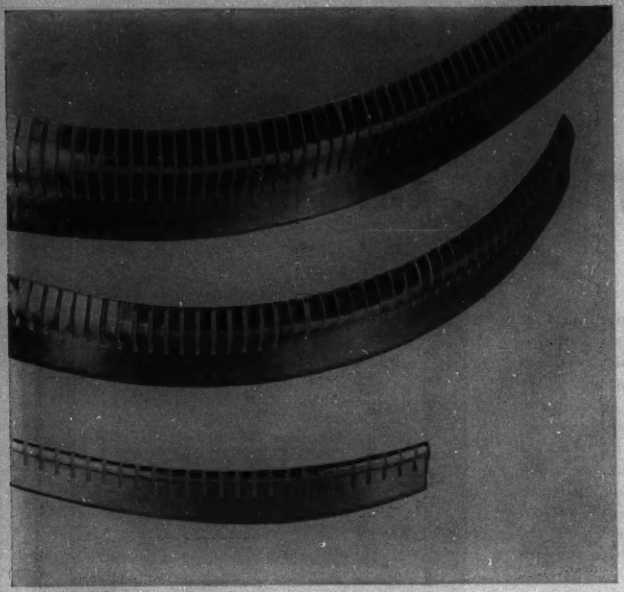
GOVERNMENT AND INDUSTRIAL DIVISION • PHILADELPHIA 44, PENNSYLVANIA

In Canada: Philco Corporation of Canada Limited, Don Mills, Ontario



Eimac finger stock

...IDEALLY SUITED FOR

- providing good circuit continuity with adjustable or moving contact surface components
- making connections to tubes with coaxial terminals
- electrical weather stripping around access doors to equipment cabinets
- making connections to moving parts such as long line and cavity type circuits

Eimac preformed contact finger stock is a prepared strip of heat treated alloy spring material slotted and formed into a series of fingers. Silver plated for efficient RF conductivity, it comes in widths of 1/22", 3/22" and 1 3/16".

For a complete Eimac Finger Stock data sheet, contact our Technical Services department.

Eimac

EITEL-McCULLOUGH, INC.
SAN BRUNO • CALIFORNIA

(*Continued from page 22A*)

Aperture Equalizer. Harrison Laboratories, Berkeley Heights, N. J., announces an aperture equalizer which provides a phaseless high boost for television. The new aperture equalizer is generally useful for "peaking-up" wide-band circuits. This instrument can be used to over-equalize a television picture to give a natural crispened effect. The new product combines a transversal-type filter with vacuum-tube circuits to obtain a symmetrical transient response. It has no phase characteristic for the same reason the aperture load itself has none; it is symmetrical. As a result of this phaseless high boost, picture detail comes through sharp and clean.

Tubeless Magnetic Amplifier. Exceptionally low ripple and precise regulation characterize the new *EM-28-1B* tubeless magnetic-amplifier-regulated d-c power supply. Developed for air-borne applications, this power supply is equally adapted to bench use in the laboratory to operate strain gauges and scientific instruments requiring precise regulation and low ripple. The unusually small size, 12 by 7 by 9 inches, was designed to fit the supply into the same space occupied by the battery it replaces. Performance tests, both in the laboratory and in military aircraft, have proved the design which calls for long, maintenance-free life while delivering continuously 1 to 1.5 amperes. For further information write to Engineered Magnetics, 11812 Teale Street, Culver City, Calif.

New Small Variable-Speed Drive. T. B. Wood's Sons Company, Chambersburg, Pa., has added a new smaller variable-speed drive to their line of standard variable-speed drives. Made with the same construction as their larger horsepower drives, they are designed to give infinitely variable speed within a 2 to 1 speed range ratio for 1- to 5-hp drives. For more detailed information, write to Gordon M. Henderson, T. B. Wood's Sons Company, Chambersburg, Pa., and ask for bulletin *497*.

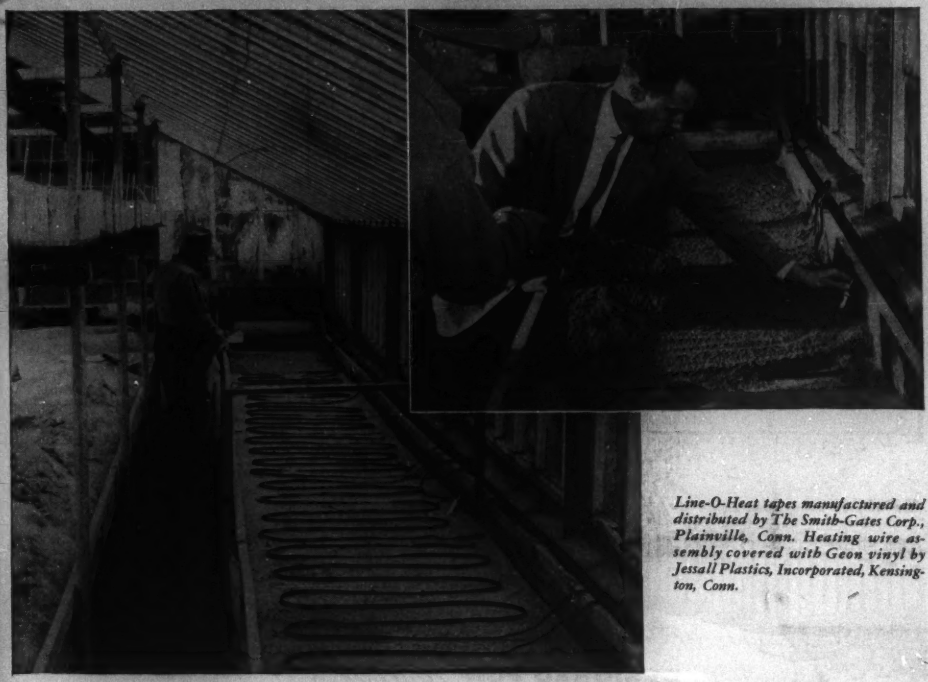
Sangamo Enters Power Capacitor Field. The Sangamo Electric Company has announced its entry into the power capacitor field with the introduction of the diaclor power capacitors, available initially in two standard ratings: 2,400 volts, 25 reactive kilovolt-amperes; and 7,200 volts, 25 reactive kilovolt-amperes. Diaclor, a noninflammable stabilized liquid dielectric, enables operation in ambient temperatures ranging from −40 C to +46 C. Full information on these power capacitors may be obtained by writing for bulletin *1720*. Address Sangamo Electric Company, Springfield, Ill.

Frequency Standard Model. The Industrial Test Equipment Company of 55 East 11th Street, New York 3, N. Y., has introduced frequency standard model *620*. This instrument can deliver up to 5 volts at a precise frequency of 60 or 120 cycles per second (factory set to within ±0.01 per

(*Continued on page 38A*)

Another new development using

B. F. Goodrich Chemical *raw materials*



Line-O-Heat tapes manufactured and distributed by The Smith-Gates Corp., Plainville, Conn. Heating wire assembly covered with Geon vinyl by Jessall Plastics, Incorporated, Kensington, Conn.

Underground sunshine sends seedlings up faster!

THE gardener can now start his biennial seedlings weeks ahead of schedule, get them to bloom the first season, through the magic of a Geon-coated heating tape called Line-O-Heat. The tape is buried in the soil, works indoors or out . . . can also be used for frost protection and jobs like thawing frozen pipes or keeping rain gutters open.

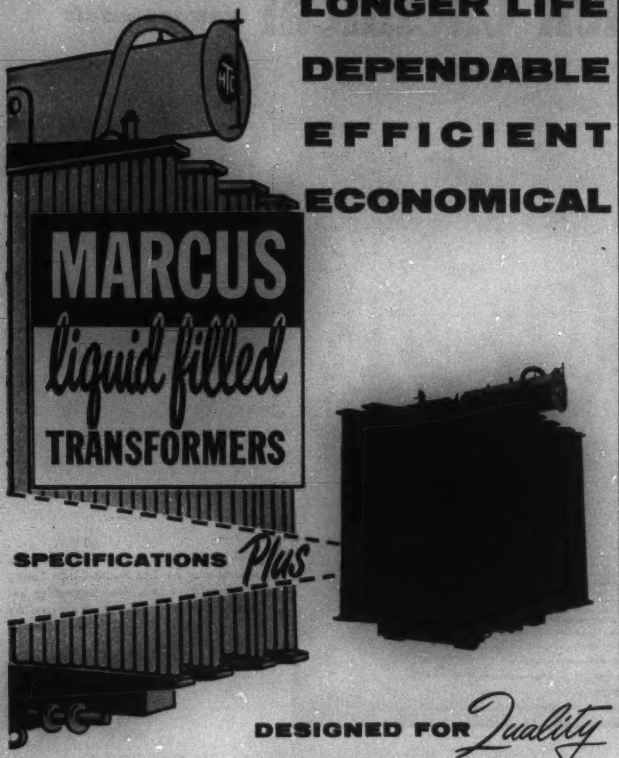
The Geon coating protects the tape's electric heating wire for years against the effects of acids, alkalis, and moisture in the soil.

Geon's remarkable physical and electrical properties make it first choice among the designers and idea men of many industries. Geon can be extruded, molded, sprayed, and dipped, and made into rigid or flexible sheets, tubing and pipe, sponge, and numerous other forms.

For complete information on Geon materials . . . and possibly the inspiration for some highly profitable ideas . . . write Dept. BH-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable.

GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors



OIL IMMERSED, ASKAREL & DRY TYPE TRANSFORMERS
Capacities 1 to 5000 KVA

- POWER
- DISTRIBUTION
- UNIT SUBSTATION
- GENERAL PURPOSE
- PHASE CHANGING
- ELECTRIC FURNACE
- RECTIFIER
- WELDING
- MOTOR STARTING
- SPECIAL

MARCUS transformers have been proven in the field by year after year of safe, trouble-free service. Leading engineers choose them for rugged dependability. At MARCUS there is no compromise with quality. Sound engineering and skilled production result in transformers that have set a new standard for the industry. The MARCUS seal on a transformer is your guarantee that you have bought the best. It is truly *"The Mark of Quality"*.

"Mark of Quality"

Representatives in Principal Cities

—MARCUS—
TRANSFORMER CO., INC.
RAHWAY, NEW JERSEY

(*Continued from page 30A*)

cent). Other frequencies, precisely set, can also be supplied upon request. Frequency stability is such that temperature variations from −40 C to +85 C or line voltage variations from 105–125 volts will affect frequency of oscillation by less than ±0.01 per cent. Output distortion is less than 1 per cent. The output amplifier is transformer coupled which presents the option of either isolated output or grounding one of the output terminals.

Push Button Timer. An improved push-button-operated electric timer is being manufactured by the Miller-Harris Instrument Company. The new *110* series timer is characterized by a heavy-duty switch, solderless snap-on terminals for easy installation, and completely enclosed switch and gear mechanisms. A wide section of timing periods—from 20 seconds to 24 hours—is available. For more detailed information, write to the manufacturer, Miller-Harris Instrument Company, 601 East Ogden Avenue, Milwaukee 2, Wis., Department A.

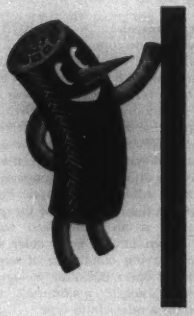
New Load Break Cutout. A new load break cutout has been announced by the R and IE Equipment Division of the I-T-E Circuit Breaker Company, Greensburg, Pa. Featured is a new lock-in device which locks the fuse holder in closed position during the load break operation permitting all arcing to be confined in the fuse tube while the load-break lever is being operated. A return of the lever to original position, after it has been pulled down, releases the safety latch and the fuse holder drops out and swings down. The current rating is 100 amperes, with interrupting capacities up to 10,000 amperes. It is available in voltages of 5.2, 7.8, 15, and 18 kv, maximum design.

Cope Cable Trough. T. J. Cope, Inc., Philadelphia, Pa., announces the development of a new *70,000* series of standard cable trough. The trough is constructed with built-in pin-type couplers at each opening which permit sections to be permanently and securely joined in a matter of seconds and will be sold in lengths of 8, 10, and 12 feet. Further information may be obtained by writing to the manufacturer for their 16-page catalogue describing and illustrating the *70,000* series cable trough with the pin-type coupler.

New Lapp Sidewall Transformer Bushing. Lapp Insulator Company, Inc., announces that it has designed and now has in production a new, complete 8.7-kv sidewall transformer bushing meeting all current Edison Electric Institute–National Electrical Manufacturers Association standards. The body is Lapp vacuum-process porcelain with clamping knob of Bakelite, especially selected to withstand weathering and aging. Clamping parts operating in tension are of silicone bronze to resist season cracking and stress corrosion. Combination arrester stud and antitorsion washer (patent pending) prevents movement of

(*Continued on page 40A*)

The miracles of modern electric illumination were all foreshadowed by the glow of Edison's first lamp—implicit in the great IDEA. Also implied in this, as in all epoch-making inventions, were the corollary imagination and effort of thousands of unpublicized successors—pioneers of America's vital electric illuminating industry.



KERITE insulation was well established before the turn of the century. Already famous in telegraphic and signal applications, Kerite quickly won recognition for safety, dependability, and ultimate economy in the infant lighting and power industry . . . for the transmission of electric power via aerial, underground, and submarine cable.

By conscientious workmanship, careful handling, and a continuing search for new and better applications of its unique formula, The Kerite Company has been able to anticipate the power industry's needs. It will continue to apply itself to the technical world of "ideas" in which now, as in Edison's day, the future of America's power still lives.

The value and service life of a product can be no greater than the integrity and craftsmanship of its maker.

Founded 1854

KERITE CABLE

THE KERITE COMPANY—30 Church St., New York 7, N. Y.
Offices also at 122 S. Michigan Ave., Chicago; 582 Market St., San Francisco; 3901 San Fernando Rd., Glendale 4, Calif.; 31 St. James Ave., Boston

NOW

Precision Attenuation to 3000 mc!

TURRET ATTENUATOR featuring "PULL-TURN-PUSH" action

FREQUENCY RANGE:
dc to 3000 mc.
CHARACTERISTIC IMPEDANCE:
50 ohms
CONNECTORS:
Type "N" Coaxial female fittings each end
AVAILABLE ATTENUATION:
Any value from .1 db to 60 db
VSWR:
<1.2, dc to 3000 mc., for all values from 10 to 60 db
<1.5, dc to 3000 mc., for values from .1 to 9 db
ACCURACY:
±0.5 db
POWER RATING:
One watt sine wave power dissipation

Send for free bulletin entitled "Measurement of RF Attenuation"

•

Inquiries invited concerning pads or turrets with different connector styles

STODDART AIRCRAFT RADIO Co., Inc.

6644-B Santa Monica Blvd., Hollywood 38, California · Hollywood 4-9294

(*Continued from page 38A*)

clamping assembly. The clamp contact parts are tinned to accommodate either copper or aluminum conductors from 1/8 to 7/16 inch in diameter. A floating anvil under 100 pounds pressure from a stainless-steel spring is effective over a range of 1/8 inch. This, combined with serrated clamping surfaces, provides excellent contact, assuring maximum conductivity, holding power against vibration, and compensation for conductor distortion.

Single-Sideband Bandpass Filter. A new single-sideband filter designed specifically for single sideband has been announced by Barker and Williamson, Inc., 237 Fairfield Avenue, Upper Darby, Pa. Design includes use of eight stabilized toroidal inductances and precision silver mica capacitors in an *LC* type filter designed to pass the frequencies 17.0 to 20 kc. The filter amplitude characteristic is relatively flat for its 3.0-kc passband with sharp skirt selectivity on both sides. Complete details are provided in bulletin *360*, available on request to Barker and Williamson, Inc.

Silicone Junction Diodes. Transitron Electronic Corporation, Melrose, Mass., announces the availability of silicone junction diodes for operation up to 150 C and featuring high forward conductance. By combining high forward conductance with high inverse resistance, they are ideally suited to nearly all low- and medium-frequency diode applications.

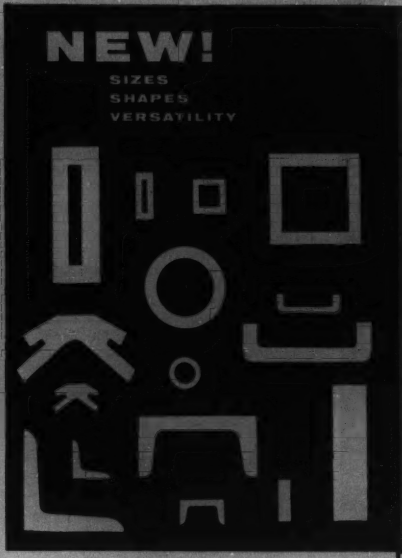
Wagner Electric Motors. A completely redesigned line of small fractional-horsepower single-phase motors, 1/4 hp and smaller, has been announced by Wagner Electric Corporation, St. Louis, Mo. These new capacitor-start and split-phase motors have shallower endplates to reduce their length materially, with ample ventilating openings located below centerline for effective dripproof construction. The company's bulletin *MU-200* gives complete information.

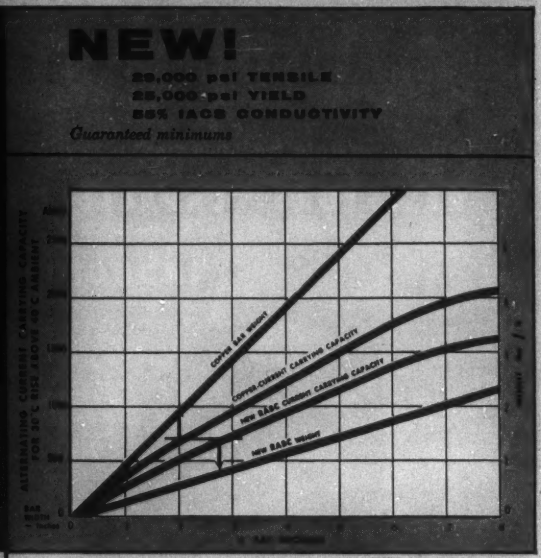
Projection Kinescope. A new RCA 5-inch projection kinescope, which produces "auditorium-size" black-and-white television pictures, up to 8 by 6 feet, when used with a suitable reflective optical, was announced recently by the Tube Division, Radio Corporation of America. The kinescope, *RCA-5AZP4*, is intended primarily for closed-circuit types of large-screen television projectors utilized for demonstration, training, and educational applications. Contributing to the brightness of the projected pictures is an aluminized white fluorescent screen having good color stability under varying conditions of screen current, and an operating ultor voltage of 40,000 volts (absolute maximum), unusually high for a tube of this type.

New Swept-Frequency Generator. The new Electromec swept-frequency generator, model *200K*, used in conjunction with an Electromec large-screen oscilloscope,

(*Continued on page 44A*)

Reynolds Aluminum Bus Conductor





Now, Reynolds gives you complete freedom in designing aluminum bus conductor installations. It is no longer necessary to specify oversize conductors because of intermediate size limitations. The new unlimited range of sizes and shapes in which RABC (Reynolds Aluminum Bus Conductor) is available permits designing to the minimum amount of metal needed for the current carrying job. The result is material costs as low as or lower than for any previous aluminum bus conductor.

Reynolds was first to develop a high strength, high conductivity, low cost aluminum bus conductor. Now, first with an unlimited range of sizes and shapes.

Added strength of the new RABC (Reynolds Aluminum Bus Conductor) has very little effect on electrical conductivity. An example from the chart above shows how favorably this new material compares in current carrying capacity. A current load of 700 amperes requires a copper bar 2" x ¼" weighing just under 2 pounds per foot; new RABC carries the same load with a 2.8" x ¼" bar weighing only ⅘ pounds per foot. The result is a 60% savings in weight. And with a lower cost per pound for RABC, an obviously big savings in cost.

ALUMINUM vs. COPPER BUS CONDUCTOR MATERIALS

PROPERTIES	COPPER	ALUMINUM EC-H17	ALUMINUM RABC
Tensile Strength (psi)	33,000 to 37,500	17,000	29,000*
Yield Strength (psi)	Not Specified	15,000	25,000*
Electrical Conductivity % IACS	98%	61%	55%*
Current Carrying Capacity†	100%	82%	79%
Resistivity @ 20°C (microhms, sq in./ft)	8.31	13.36	14.82
Modulus of Elasticity (lb/in.²)	16 x 10⁶	10 x 10⁶	10 x 10⁶
Density (lb/in.³)	.322	.09765	.09765
Temp. Coeff. of Resistance (% per°C @ 20°C)	.393	.403	.360

*Guaranteed minimum. †For given temperature rise and same cross section.

CALL ON REYNOLDS ENGINEERING SERVICE Reynolds engineers will conduct meetings with your men and provide them with the latest information on all electrical applications of aluminum. Also write for more complete information on the revolutionary RABC and a complete index of design and fabrication literature. *Reynolds Metals Company, 2541 South Third Street, Louisville 1, Kentucky.*

"See Mr. Peepers", starring Wally Cox, Sundays on NBC-TV

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

SIE

MODEL E-2

COMPARISON BRIDGE

for fast, accurate matching and measuring of

RESISTORS 1 ohm to 5 megohms

CAPACITORS 500 mmfd to 2000 mfd

INDUCTORS 3 millihenrys to 10,000 henrys

Sloping meter face and wide-spaced component clips speed production line testing. Foot operated switch* allows two-hand operation.

Stable, high-gain, circuit permits the detection of component differences amounting to only 1 part in 10,000. Five meter ranges indicate differences at 1%, 2.5%, 10% and 25% value full scale.

In the design laboratory, or in assembly operations, the E-2 Comparison Bridge offers accuracy, flexibility, and dependability.

★ EASY TO USE—
Spring clip, and banana plug terminals.

★ HAND OR FOOT OPERATED—
*Foot control optional at extra cost.

★ ACCURATE—
Tolerance 0.1% on 1% scale.

★ LOW COST—
$195 FOB Houston.

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.
INDUSTRIAL INSTRUMENT DIVISION
P. O. Box 13058 2831 Post Oak Road Houston, Texas

205.55 REPRESENTATIVES THROUGHOUT THE WORLD

(*Continued from page 40A*)

provides an instantaneous and continuous visual display of frequency response of a device under test. This new product enables the designer to determine instantly the effects of changes in circuit parameters upon frequency characteristics, thus permitting optimum designs to be obtained in minimum time. For information write to the Engineering Department, Electromec, Inc., 3200 North San Fernando Boulevard, Burbank, Calif.

UHF Television Tuner. A new uhf television tuner developed to meet the r-f interference objectives of both the Radio-Electronics-Television Manufacturers Association and the Federal Communications Commission has been announced by the Radio Condenser Company, Davis and Copewood Streets, Camden 3, N. J. Designated model *T-90*, the new tuner features a rearrangement of the usual television tuner components and better shielding which combine to act as oscillator radiation fixes, thereby preventing the oscillator from radiating interference outside the recommended limits. Bulletin *T-90* describes the tuners fully and is available upon request to the company.

TRADE LITERATURE

Cenco News Chats Available. "Cenco News Chats," number *80*, published by Central Scientific Company, includes articles on the following: the American Institute of Electrical Engineers; Michael Pupin, late professor of electromechanics at Columbia University; and the importance of instrument selection in education and research. The 24-page booklet also contains information and photographs on a number of new scientific instruments, apparatus, and supplies. A copy of the publication may be obtained by writing to Central Scientific Company, 1700 Irving Park Road, Chicago, Ill.

Alloy Steels. A 200-page handbook entitled "Alloy Steels Pay Off" is offered by the Climax Molybdenum Company to engineers and purchasing and management personnel interested in alloy steels in modern equipment design. Covered in this book are the economic advantages of fabricating with alloy steels, advantages of high impact strength and shock-load resistance, as well as savings resulting from improved resistance to corrosion and wear. Copies of this informative book have been distributed to colleges and universities, free of charge. Technical, administrative, and equipment maintenance personnel wishing to obtain copies may write directly to the Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y.

Television Picture Tube Guide. CBS-Hytron, a division of Columbia Broadcast-

(*Continued on page 54A*)

FRAHM® TACHOMETERS

HAND AND MOUNTING TYPES
THE TACHOMETERS THAT
REQUIRE NO MAINTENANCE

Accurate—Safe—Easy-to-Use

No contact with moving parts—simply touch it to the case or frame of the machine under test and read directly in rpm. No wearing parts—no oiling—cannot be injured by overspeeding.

Mounting types are supplied with brackets for permanent mounting on turbines, pumps, generators, etc.

IDEAL FOR PRODUCTION TESTING where quickness and accuracy count. Bench mounted, with stimulator rods, the Frahm Tachometer becomes a time and money saver for inspecting hand power tools, electric shavers, cleaners, and many others too numerous to mention.

FRAHM® FREQUENCY METERS

AS SIMPLE AS A TUNING FORK
AND JUST AS DEPENDABLE
AND DURABLE

Portable, Mounting and Sealed Types in a wide variety of ranges. Indicate alternating current frequency from 15 up to 1500 cycles per second. Applicable to pulsating or interrupted d-c as well as a-c supply circuits.

Frahm Frequency Meters are available in switchboard, miniature and portable types in a wide variety of ranges. Specially designed instruments can be made to your specifications. We invite correspondence regarding applications which require special modifications of range, methods of actuating, scale graduations or other design characteristics.

These and other publications are available to you for the asking—we will send you a complete list of our literature with the material you request at the right.

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Company _____

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Get this helpful booklet! In addition to details on Stackpole products, this 44-page Booklet 40A includes helpful engineering discussions on the physical and electrical properties of carbon and graphite. Copy sent free on letterhead request.

- GRAPHITE TUBE ANODES
- BATTERY CARBONS
- GROUND RODS
- NON-WELDING ELECTRICAL CONTACTS
- VOLTAGE REGULATOR DISCS (carbon piles)
- WATER HEATER and PASTEURIZATION ELECTRODES
- BEARINGS
- WELDING RODS
- WELDING PLATES and PASTE
- RESISTANCE WELDING and BRAZING TIPS
- CHEMICAL CARBON and GRAPHITE (Plain or Treated)
- CARBON RODS FOR SALT BATH RECTIFICATION
- TROLLEY SHOES
- SEAL RINGS
- FRICTION SEGMENTS
- CLUTCH RINGS
- BRAZING FURNACE BOATS
- ELECTRIC FURNACE HEATING ELEMENTS
- MOLDS and DIES
- CONTINUOUS CASTING DIES

STACKPOLE CARBON COMPANY
St. Marys, Pa.

EVERYTHING IN CARBON BUT DIAMONDS

(*Continued from page 44A*)

ing System, Inc., has announced the second edition of its comprehensive "CBS-Hytron Reference Guide for Television Picture Tubes." The enlarged television picture tube guide lists all magnetically deflected picture tubes to date, monochrome or color, including those made by other manufacturers. Basing diagrams and pertinent data for 242 tubes are presented. The television picture tube guide is available, free of charge, from CBS-Hytron distributors.

Electric Equipment. A 32-page booklet, "Electrical Equipment You Can Build," is available from the Westinghouse Electric Corporation. Designed for use in 4-H Electric Programs, and other rural youth programs, the booklet has plans for more than 50 pieces of equipment that can be built around the home or on the farm. The new booklet contains plans for lighting equipment, shop equipment, signal systems, and productive equipment for farms. Copies of this booklet, *B-6511*, are available to power suppliers for $4.50 a hundred. Single copies will be mailed free of charge. Write to Westinghouse Farm Youth Activities, P. O. 2278, Pittsburgh 30, Pa.

High Fidelity Catalogue. Allied Radio Corporation has announced a 68-page publication entitled "This Is High Fidelity," which contains information explaining high fidelity, and includes listings of high-fidelity music systems and separate components. This publication, number *144*, is available, without charge, from Allied Radio Corporation, 100 North Western Avenue, Chicago 80, Ill.

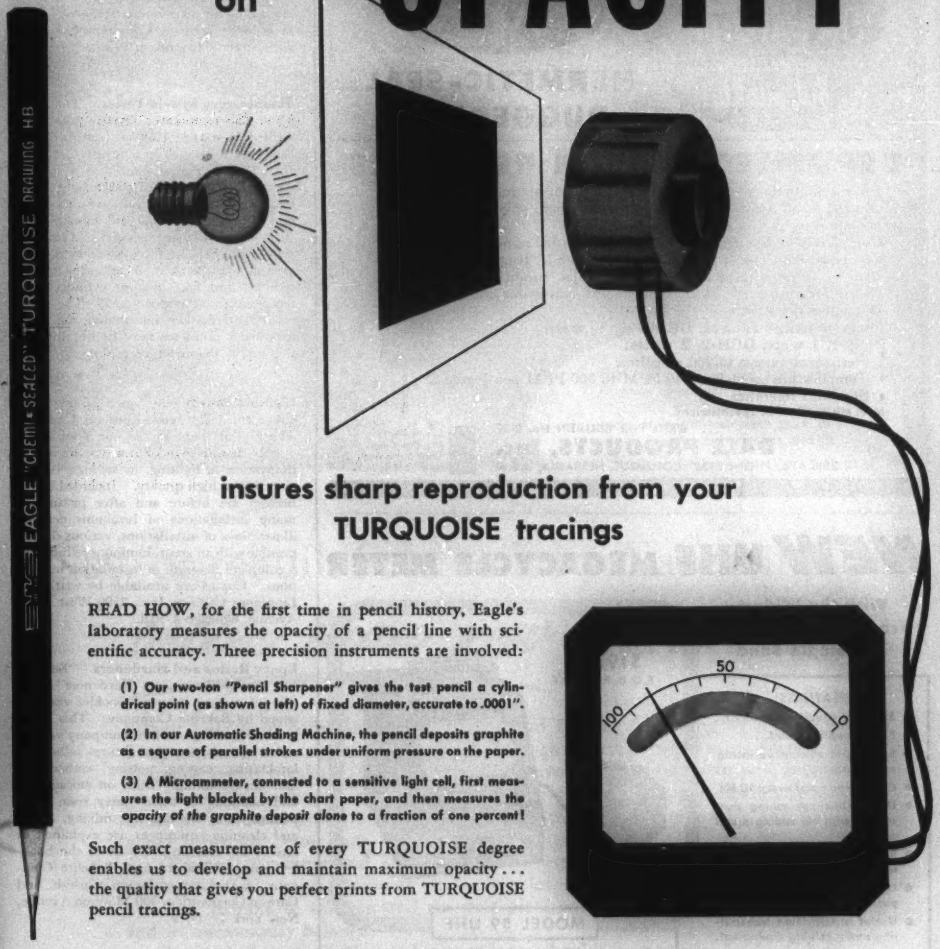
R-F Interference Filter Catalogue. A 22-page combined catalogue reviews the Filtron Company's complete line of type *FSR* r-f interference suppression filters for use in screen rooms, induction heating equipment, diathermy and X-ray units, or similar equipment which may produce radio interference. Detailed information on each filter is given. Graphs of attenuation characteristics and engineering data help the user to select and specify the right filter. Copies of the catalogue may be obtained from Filtron Company, Inc., Flushing, N. Y. Request catalogue *FSR*.

Turbine-Generators Described. General Electric Company turbine-generators, rated from 2,500 to 40,000 kw, are described in a new booklet designated *GEA-3277C*. Condensing and noncondensing applications for electrical utilities and industrial plants, as well as special turbine applications, are covered in this publication. The 54-page booklet can be obtained from the General Electric Company, Schenectady 5, N. Y.

Bulletin on 3-Pole Subway Oil Switches. Design, construction features, and general dimensions of Allis-Chalmers' 3-pole non-

(*Continued on page 62A*)

A new light on OPACITY



insures sharp reproduction from your TURQUOISE tracings

READ HOW, for the first time in pencil history, Eagle's laboratory measures the opacity of a pencil line with scientific accuracy. Three precision instruments are involved:

(1) Our two-ton "Pencil Sharpener" gives the test pencil a cylindrical point (as shown at left) of fixed diameter, accurate to .0001".

(2) In our Automatic Shading Machine, the pencil deposits graphite as a square of parallel strokes under uniform pressure on the paper.

(3) A Microammeter, connected to a sensitive light cell, first measures the light blocked by the chart paper, and then measures the *opacity of the graphite deposit alone* to a fraction of one percent!

Such exact measurement of every TURQUOISE degree enables us to develop and maintain maximum opacity . . . the quality that gives you perfect prints from TURQUOISE pencil tracings.

PROVE IT IN THE PRINT with a free TURQUOISE sample.
Just write us, naming this magazine and the grade you prefer.

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*"Chemi-Sealed" (Super Bonded)
*TURQUOISE *Drawing Pencils & Leads*
With 100% *"Electronic" Graphite

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DEPOSITED CARBON RESISTORS

Produced under the most exacting methods of quality control. Ideal for use in UHF equipment where only the optimum of quality may be tolerated.

Completely high temperature alloy solder sealed in newly developed envelope of non-hydroscopic ceramic. Ruggedized for incorporation into "snap-in" clips. Production tested for resistance to thermal shock, salt-water immersion and humidity.

Three wattage ranges: DCSH-½, ½ watt; DCH-1, 1 watt; DCH-2, 2 watts.

- Resistance ranges to 200 megohms
- Temperature coefficient 140 PPM to 500 PPM per degree C
- Standard tolerance 1%

Meet MIL-R-10509-A Specifications

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DALE PRODUCTS, Inc.

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Export Dept.: Pan-Mar Corp., 1270 Broadway, New York 1, N.Y.

NEW UHF MEGACYCLE METER

With the Widest Frequency Coverage in a Single Band

FEATURES

- Excellent coupling sensitivity.
- Fixed coupling point.
- Small grid current variation over band.
- Calibration point every 10 Mc.
- Uses split-stator tuning condenser with no sliding metal contacts.
- Standard camera socket for tripod fixtures.
- Octagonal case for convenient positioning.
- Useful in television transmitting and receiving equipment.

$198.00
F.O.B. FACTORY

MODEL 59 UHF

SPECIFICATIONS

FREQUENCY RANGE: 430-940 Mc in a single band
FREQUENCY ACCURACY: ± 2% (individually calibrated)
OUTPUT: CW or 120-cycle modulation
POWER SUPPLY: 117 volts, 60 cycles, 30 watts
DIMENSIONS: Oscillator Unit 4½" x 2½"
Power Unit 5½" wide x 6¼" high x 7½" deep

Laboratory Standards **MEASUREMENTS CORPORATION**
BOONTON · NEW JERSEY

(Continued from page 54A)

automatic subway oil switches are given in a new bulletin published by Allis-Chalmers. Two types of switches are described—type *M-25*, rated 300 amperes, 5,000 volts; and type *M-50*, rated 400 amperes, 7,500 volts. Copies of the bulletin, "Allis-Chalmers 3-Pole Subway Oil Switches," *71B601B*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Temperature System Tester. The Jetcal jet engine temperature system tester, described in a new 12-page brochure published by B and H Instrument Company, Inc., 1009 Norwood, Fort Worth 7, Tex., checks the accuracy of thermocouple systems right on the aircraft, or on the engine's production line in manufacture. Also described are special "Tempcal" probes for checking the thermal switches of aircraft overheat detectors and wing anti-ice systems, and for checking cylinder head temperature thermocouples. The brochure and further information on heat-measuring problems may be obtained by writing the manufacturer.

Lighting Brochure. A new 16-page brochure entitled "Acusti-Luminus Ceiling—The Ceiling That Works For You!" thoroughly describes and illustrates the newest innovation in lighting, its savings, its efficiency, and high quality. Included in this booklet are before and after pictures of many installations of luminous ceilings, illustrations of installations, various designs possible with an acusti-luminous ceiling, and a complete diagram of installation instructions. Copies are available by writing to Luminous Ceilings, Inc., 2500 West North Avenue, Chicago 47, Ill.

Epoxy Resins and Hardeners. "Bakelite C-8 Epoxy Resins and Hardeners" is the title of a new 16-page booklet recently issued by Bakelite Company. This booklet describes the use of the company's epoxy resins for tools, dies, jigs, fixtures, adhesives, laminating, casting, potting, embedding, and encapsulating. Data on storage life and handling of these epoxy resin compounds, their working life, mixing, fillers, and cleaning equipment are explained in one of the sections. Copies of the booklet may be obtained from Bakelite Company, a Division of Union Carbide and Carbon Corporation, 300 Madison Avenue, New York 17, N. Y.

Industrial Solenoids. A bulletin describing the complete new line of strongbox industrial solenoids is available from the General Electric Company, Schenectady 5, N. Y. The 4-color 16-page publication contains information on product features, laboratory tests, and general application rules. A cross-reference chart equates this new line with corresponding models in the former line, and shows the proper model to be chosen for given requirements of force and stroke. Designated *GEA-6215*, the

(Continued on page 64A)

Part of a set of 16 field coils recently completed by National for a 25,000 KVA waterwheel generator. Note the complete pole assembly ready for mounting on the rotor.

New or rebuilt field coils by National mean *better than new* performance

Salient pole field coils deteriorate in time and require rebuilding or replacing. They are subject to copper growth, lead breakage, shorts between turns, looseness on poles, collar breakage, breaking apart of turns, and grounding to pole pieces.

Corrective measures include the use of silver bearing copper, flexible leads, Class 'B' turn and pole piece insulation, and asbestos bakelite collars and staggered turns for better heat dissipation and longer life.

Trained personnel and heavy specialized equipment are at your command to expeditiously repair, rebuild or replace large fields; road service men are available to remove and reinstall the pole piece and coil assemblies on the rotor and to dynamically balance.

Write, wire, or call National, or get in touch with your nearby National field engineer.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

24-CHANNEL PULSE-POSITION-MULTIPLEX RADIO SYSTEM OF ADVANCED DESIGN

This equipment provides 24 broad-band telephone channels in the frequency range 2450 to 2700 mc. with toll-grade transmission performance over very long systems. Full provision is made for branching, dropping and inserting channels, and elaborate fault-reporting and automatic changeover features are available. Transmitter has 5 watts average output power. Antennas, transmission line, 4-wire terminating, ringing and dialling sets and test equipment are available to form complete packaged systems of superb performance, reliability and quality.

A similar system is produced for the frequency band 235 to 328 mc.

Type PPM24/2500 Radio Bay is 22" wide by 18" deep by 64" high. The 24-channel multiplex bay has the same dimensions.

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MANUFACTURERS OF CARRIER-TELEGRAPH, CARRIER-TELEPHONE AND BROAD-BAND RADIO SYSTEMS

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CONTINENTAL APPARATUS CABLE, BOILER ROOM WIRE, HEADLIGHT WIRE, MINING CABLE, MOTOR LEAD CABLE, POWER CABLE, SWITCHBOARD WIRE OR CABLE.

Serving 600 to 5,000 volts, in sizes 18 AWG to 2,000,000 CM:
HEAT- & MOISTURE-RESISTANT WIRES, CABLES & CORDS for

Air Conditioners, Airplanes, Bakeries, Bake Ovens, Ballast Transformers, Boiler Rooms, Busses, Control Stations, Clothes Dryers, Commercial Refrigerators, Cranes, Dry Kilns, Electric Furnaces, Electric Motors, Electric Ranges, Electronic Equipment, Hair Dryers, Heat Controls, Heating Elements, Infra-red Heat, Lighting Fixtures, Locomotives, Mercury Switches, Motion Picture Machines, Oil Burners, Panel Boards, Paper Mills, Power Houses, Pyrometers, Radios, Range Lights, Range Timers, Resistance Soldering, Restaurant Equipment, Rheostats, Sewing Machines, Show Case Lights, Smokehouses, Soldering Irons, Spotlights, Stage Lights, Steel Mills, Switchboards, Table Stoves, Television Sets, Thermostats, Toasters, Waffle Irons, Water Heaters

Type for type, CONTINENTAL Wires and Cables supply among the *highest rated temperatures, highest current capacities, widest range of sizes* available.

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SALES: Box 363, Wallingford, Conn.
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(Continued from page 62A)

bulletin also shows force and current curves, and dimensions for both push and pull types.

Chart Offered. Design engineers, electronics purchasing departments, radio-television servicemen, and other users of fixed composition resistors and capacitors will find much use for a new plastic wall chart offered by the Electronic Components Division, Stackpole Carbon Company, St. Marys, Pa. Using the wall chart as a guide, an engineer may develop almost any circuit using standard resistors and capacitors. Since the complete range of Radio-Electronics-Television Manufacturers Association values and tolerances encompassed by Stackpole circuit elements permits use of standard parts exclusively, the need for specifying or ordering costly special components within this range is eliminated for nearly all applications. Copies of the 8- by 11-inch chart are available on letterhead request.

Power Connectors. Power connectors for use with aluminum and copper conductors for every application are listed in a new catalogue published by Delta-Star. An extensive data section to assist in estimating, planning, and engineering is included in this catalogue. Other sections cover connectors for tubing-to-tubing; cable-to-cable; tubing-to-cable; tube or bar; square tubing; flexible connectors; grounding and stud connectors; and terminal lugs. Copies of this publication can be obtained from Delta-Star Electric Division, H. K. Porter Company, Inc., of Pittsburgh, located at 2437 Fulton Street, Chicago 12, Ill., or any of its district offices.

Burndy Crimpit Bulletin. The many recent developments in the Burndy Crimpit (registered trade-mark) line of compression connectors for overhead distribution connections are included in the new 27-page Crimpit bulletin *CR-1*. Information on the entire Crimpit connector line for all overhead distribution applications, including aluminum triplex service connections, are described. For a copy of this publication write to Burndy Engineering Company, Inc., Norwalk, Conn.

Vacuum-Tube Electrometers. A new 12-page catalogue describing vacuum-tube electrometers and accessories has been released by Keithley Instruments, 3868 Carnegie Avenue, Cleveland 15, Ohio. The catalogue includes introductory data on electrometer characteristics, circuit discussions, and equipment photographs.

Panelboard Bulletin. A new 24-page bulletin, number *501*, describing a complete line of lighting and distribution panelboards for industrial and commercial use is announced by Continental Electric Equipment Company, Box 1055, Cincinnati 1, Ohio. All panelboards are illustrated, and construction design and application features are given as well as ratings, weights, dimensions, and knockout arrangements.